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AND

THE PHYSICAL SOCIETY

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The inclusion of particulars of a vacancy must not be taken to imply that the Institute and Society necessarily approves of the terms offered or that might be offered. Candidates should satisfy themselves that these are satisfactory, and they may always refer to the Institute and Society for advice.

MEMORIAL UNIVERSITY OF NEWFOUNDLAND

To meet the needs of an increasing enrolment and an expanding programme, the Memorial University of Newfoundland invites applications for the following positions for 1961-1962, appointments to become effective September 1, 1961. FACULTY OF ARTS AND SCIENCE. DEPARTMENT OF MATHEMATICS. An ASSISTANT or ASSOCIATE PROFESSOR for undergraduate teaching. DEPARTMENT OF PHYSICS. An ASSISTANT PROFESSOR of NUCLEAR PHYSICS (low energy) and an ASSISTANT PROFESSOR of THEORETICAL or ATMOSPHERIC PHYSICS to teach up to the Master's level and for research in his area of specialization. The salary scale is : for Assistant Professors $6500 to $7000, for Associate Professors, $8000 to $8500. The University will be moving to a new campus during the summer of 1961 and adequate facilities will be available for research. All appointments are provisional for two years. The University has a liberal contributory pension scheme. Travel expenses incurred in taking up an appointment are payable up to a maximum of $750. Applications should be sent immediately, and preferably by air-mail, to the President, Memorial University of Newfoundland, St. John's, Newfoundland, Canada, giving a complete curriculum vitae, the names and addresses of three referees and enclosing a recent photograph. Applicants should also lodge one copy of their application with the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1.

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THE BRITISH CERAMIC RESEARCH ASSOCIATION has vacancies for GRADUATE CHEMISTS or PHYSICISTS to work in the Pottery Section of the Association. There is also a vacancy for an ORGANIC CHEMIST to work primarily on adhesives and grouting materials. Good Laboratory facilities are available. The post is permanent and progressive and carries superannuation provision under the Federated Superannuation System for Universities. Salary will depend on age, qualifications and experience but will be in the range of £720–£1,090 for a Scientific Officer, and £1,100–£1,600 for a Senior Scientific Officer. Applications giving details of age, qualifications and experience should be sent to the Director, The British Ceramic Research Association, Queens Road, Penkhull, Stoke-on-Trent.

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BULLETIN
OF
THE INSTITUTE OF PHYSICS
AND
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Vol. 12, No. 3 MARCH, 1961

The Endless Frontier

Professor W. H. G. ARMYTAGE, M.A.

University of Sheffield

[A lecture given to the Manchester and District Branch on October 24 1960] *

SIX PROPENSITIES, according to W. W. Rostow in *The Process of Economic Growth* (1953), can be seen at work in the evolution of modern society. They are the propensity to develop fundamental science, the propensity to apply it to economic ends, the propensity to seek material advance, the propensity to accept innovation, the propensity to consume and the propensity to procreate.

There is a frame of reference in which these propensities operate : a frame which I am going to outline briefly. The pattern within the frame is of a society which makes an ever increasing use of energy slaves provided for it by physicists. You may complain that this metaphor is a contradiction of the title of my lecture. Not at all. For the frame, like a television screen, shows an endless Western, orchestrated with cracks and bangs, fast pursuits and captures, with a relentless pressure of events spurring the story along. And Westerns take place on a frontier.

To many of you, the title of the lecture is familiar, for it was used by Vannevar Bush for his report to the President of the United States after the second world war : a report which triggered off (if I may ride that metaphor for a bit longer) the establishment of the National Science Foundation in the U.S.A. In that report Vannevar Bush argued that " the government should accept new responsibilities in promoting the flow of new scientific knowledge and the development of scientific talent in our youth " in order " to foster the opening of new frontiers ".

Let us look at these new frontiers for a moment.

POWER : PAST AND FUTURE

One seventh of all the people who have ever been alive are alive to-day. The expectation of life, thanks to technological developments, has increased from 30 years, in the time of Augustus, to 70. The enormous rate of increase is such that, if it continues, to-day's population will double itself in fifty years. Palmer C. Putnam has calculated that from the death of Christ to the beginning of the American Civil War, the total energy consumption of the world was from 6 to 9 Q (Q = 10^{18} B.T.U.), i.e. ·45 Q per century. From the beginning of the American Civil War to 1947 (i.e. 87 years) it was about 4 Q, i.e 4·5 Q per century. Now it is equivalent to 20 Q per century, and by the year 2000 is expected to be 100 Q per century.

Of the energy reserves at mankind's disposal, coal will (it is estimated) supply 36 Q, oil 6 Q and uranium from 100 to 1000 Q (depending on the improvements in its use). Apart from these, and new man-made fuels which at present would need a great deal more research to be really practicable, there are five other sources of energy: wind, solar energy, tidal power, earth heat, sea temperature differences. The first of these has been explored by Palmer C. Putnam, who with Professor J. B. Wilbur of the Massachusetts Institute of Technology, constructed an experimental 1250 kW wind turbine at Grandpa's Knob in Vermont which operated with great success. Its performance, reported in *Power from the Wind* (1948), has inspired the construction of an experimental 100 kW windmill, run in conjunction with a diesel electricity generating station, at Costa Hill in the Orkneys. There are several hundred other sites in Britain where the wind can be similarly trapped to save some 4,000,000 tons of coal. Sir David Brunt has calculated in *Physical and Dynamic Meteorology* (1933) that the convertible total power in the atmosphere is 3×10^{17} kW. The Russians refer to it as " blue " power and have a number of experiments in train.

The concept of the second source, solar energy, has tempted man to tap it since the time of Archimedes, but the first serious discussion of it was a thesis written by John Ericcson in 1868. Ericcson made the first sun motor by using at New York a cylindrical mirror of parabaloid section with a cylindrical boiler in the focus line. By 1875 he had made seven sun-motors. He obtained 1 h.p. per 100 square feet of mirror—and obtained about 10 per cent efficiency. To utilise solar energy, he developed his caloric engine. Other engineers who have worked on solar energy include Carl Gunter of

* Part of this material will appear in a book to be published by Faber and Faber in 1961 entitled *The Social History of Engineering*

Austria ; A. Mouchot and A. Pifre of France, and Henry Bessemer in England. In India William Adams constructed in 1876 a mirror-operated boiler with a steam train and pump at Bombay. In Chile, J. Harding built a water distiller that worked by solar power. In California, at Ostrich Farm Pasadena, A. G. Eneas used 33ft. 6in. diameter mirrors to obtain heat. In Egypt Sir Charles Boys was a consultant to a large power plant built at Cairo in 1912. Solar water heaters have been built by the thousands in the southern part of the U.S.A. in the form of heat absorbers on the roof, whilst Dr. Ghai, the Assistant Director of the Indian National Physical Laboratory, has utilized it for cooking.

In 1940, the possibilities of solar energy were such that Godfry L. Cabot bequeathed an endowment to the Massachusetts Institute of Technology of work on photo chemistry, thermoelectricity and other various applications for the principle. The then president of Harvard, J. B. Conant, was very interested in the possibilities. In 1953 the University of Wisconsin published *Solar Energy Research*, a result of a symposium organized on the subject. Solar energy is being more directly used in the United States. Photo-synthesis, the activation of silicon discs to produce electricity (one impregnated with arsenic as a negative, the other with boron as a positive) and the energizing of cadium sulphide crystals are three of the present uses.

Tidal power (the third source), suffers from two obvious disdavantages. There is no power at times of flood and ebb, and moreover these times change by forty minutes each day. J. B. S. Haldane has warned us of another: in his view, the development of tidal power would increase the braking action of the tides so that the rotation of the earth would slow down, the day would therefore become longer, and the moon would approach the earth. Yet, in spite of these warnings, the engineers have let their imaginations and energies loose on tidal power ever since the century after the Norman Conquest, when tidal mills were operating off the English coast. Peter Morrice's tidal wheels were operating on the system on the Seine near Havre. Kaplan turbines, with blades of adjustable pitch, have suggested themselves in many quarters. Four main projects have received detailed study : the Severn Barrage (first proposed in 1849, studied in model form in 1947, and estimated to effect a saving of a million tons of coal) ; the Estuaries Scheme, in the Bay of Fundy in Canada ; the Passamaquoddy Scheme in Maine, U.S.A., and the Rance and Mont St. Michel schemes, in Brittany. Britain is particularly well endowed for enterprises of this kind, with some 66 favourable sites for tidal power stations.

The fourth source of power has perhaps received the least attention. In 1904 Parsons suggested to a large conference of engineers that a deep borehole should be made in the earth's crust to tap steam. He gave an estimate of its cost. To-day, at Larderello in Italy, steam piped from subterranean volcanoes gives energy convertible to electric power, whilst the Russian Academy of Science has one of its research teams working on earth heat in Kamchatka.

The last power source, utilizing temperature differences in the sea, is still being explored. At Abidjan on the French Ivory Coast there is a project which aims at using the difference between surface and sea-depth temperature as a power source.

ELECTRONIC COMPUTERS

Of all energy slaves, the most significant are those which supplement and supplant human thought. In 1935 a young English mathematician, A. W. Turing, investigated the possibility of a machine being constructed to carry out mathematical problems. This was actually built in the United States at the Massachusetts Institute of Technology by the International Business Machine Corporation on mechanical principles. Christened "Bessie" (after the German mathematician F. W. Bessel) it was capable of adding 15,000 numbers, and worked through punched cards. It proved a great help to the United States for various missile and bombing calculations. But its greatest accomplishment was to calculate the mathematical problems concerned with nuclear fission. This took 103 hours to accomplish.

The development of electronic computers began when two electrical engineers, Vannevar Bush (1890-) and O. H. Caldwell (1888-) joined forces. Caldwell was editor of the American Journal *Electronics*. Bush had been with the General Electric Company, a teacher of mathematics at Tufts College, and specialized in submarine detecting services in the first World War, becoming Professor of Electric Power Transmission at the Massachusetts Institute of Technology. In 1929 he published a book, *Operational Circuit Analysis*, and built a differential analyser—a machine for solving differential equations.

The next stage was the construction of an Electronic Numeral Integrator and Computer (E.N.I.A.C.), the result of further needs in ballistic calculation, and begun in 1942 at Harvard under Professor Howard Aitken by J. W. Mauchly and J. P. Eckert. Howard Aiken (1900-) was formerly an engineer with the Madison Gas and Electric Company and the Westinghouse Electrical Manufacturing Company before joining the staff at Harvard in 1939. By 1946 he was director of its computation laboratory. J. P. Eckert (1919-) went on to design B.I.N.A.C. in 1946-49 (the Binary Automatic Computor which has two brain valves which check each other and is portable) and U.N.I.V.A.C. in 1948-51 (the Universal Automatic Computer for the American Statistical State Bureau for the evaluation of the 1950 census). He and Mauchly set up the Computer Corporation in 1947 which was taken over by Remington Rand and by the Sperry Rand Corporation.

One of those engaged on the construction of E.N.I.A.C. was the English physicist, D. R. Hartree, who after anti-aircraft research in the first World War had been Beyer Professor of Applied Mathematics at Manchester from 1929-37 and later Professor of Theoretical Physics. During the second World War he was acting Chief of the Institute of Numerical Analysis, U.S. Bureau of Standards. He built the first machine at the N.P.L. laboratories at Teddington, known as A.C.E. (the Automatic Computing Engine), which was a considerable advance on E.N.I.A.C. with 4,500 valves. The University of Manchester followed this up under F. C. Williams and A. W. Turing, and Professor Williams was, for his work with Ferranti's and on this, awarded the first

Franklin medal. The stage was set for even more rapid development under the aegis of the National Research Development Corporation.

Apart from the impact of computers on industrial production, one of the interesting consequences of the growth of electronic computing techniques was the entry of the famous catering firm of J. Lyons and Co. Ltd. into the engineering industry. This firm had established an Organization and Methods Office as early as 1922, and after a two-year period of trial and experiment, decided to utilize a similar computer for their weekly pay-roll and for information on which to base their buying and pricing. Their computer did the work of 200 to 400 clerks and occupied only 1,150 square feet, and time on it was soon hired out to other firms and government departments. It was so successful that a new company was subsequently formed to manufacture electronic office equipment : Leo Computers Ltd.

The rapid development of analogue machines and computers, coupled with the war-time advances in servo-mechanisms, made it possible to visualize an automatic factory. These two trends, grafted on to the existing tendency to run assembly lines in factories, led to the convening in June 1955 by the Institution of Production Engineers of a conference on "The Automatic Factory—What does it mean ?" They concluded that there was no reason to fear technological unemployment. The Department of Scientific and Industrial Research regarded automation in a report issued in the following year as an expansion of the scope of mechanization and materials-handling. The Amalgamated Engineering Union, however, adopted a different attitude. They suspected unemployment and resolved that the worker had a right to keep his post if affected by automation. The Trades Union Congress, however, have adopted a co-operative and constructive attitude which augurs well for the future.

Automatic controls made it possible to produce motor cars, chain cables, steel tubes and printed circuits with a rapidity and exactness hitherto unequalled.

But the prime utilization of automation was in the new nuclear power stations. Hinkley Point was designed at a capital cost of £105 per kW as opposed to the £120-£140 per kW for Berkeley, Bradwell and Hunterston. Analogue computers can now simulate the performance of a complete nuclear power station and enable the automatic control systems to be planned.

Yearly, almost monthly, improvements in the electronics that underlie automation are being recorded, notably at institutions like M.I.T. Cryotrons are replacing vacuum tubes ; transistors are making computers lighter and simpler ; automatic readers are facilitating communication ; automatic chemical analysers are enabling chemical engineers to obtain quick visual checks of their processes. The full history of the movement will make exciting reading.

THE PROBLEMS OF TECHTOPIA

The energy-slaves at mankind's disposal have enabled more people not only to live, but to live more abundantly than ever before. Electricity (unlike steam power) by no means involves that they live in large asphalt jungles. On the contrary, it has made tolerable life in country places and encouraged decentralization. It has (through television) given a medium to the very prophets of woe, enabling their misgivings to be communicated to millions.

The problems of techtopia are not that technology has gone too far and too fast, but that its benefits are not shared equally throughout the world. It is true that it cannot be packaged and exported to backward areas, however gently, without disrupting their culture. Current indications of international responsibility for ensuring that all nations acquire better techniques of food growing, enhanced awareness of their national resources, and adequate supply of modern chemicals to combat disease, plagues, and death, are being accomplished by a thoughtfulness and care by the World Federation of Mental Health to ensure that change does not detonate an explosion. Yet the problem of the backward areas is such that it may well be a race between donations and disaster. Some two-thirds of the 3,000,000,000 people of the world are increasing their population at such a rate that Sir Charles Darwin, in a particularly gloomy prognosis *The Next Million Years* (1952), foresees a densely crowded world with a population slowly approaching the margin of existence and compelled to work every day harder and harder. For, though the backward nations of the world are becoming industrialized, the rate of the industrialization does not seem to be closing the gap between themselves and the West. Measured in terms of net income per head this gap is formidable, for the United States has a net income per head fifty times greater than that of China. That is why an energetic policy of mutual aid is so essential on the part of the advanced nations.

In techtopia itself, multiple problems present themselves. The first is the intensive face-to-face nature of society and the channelling of temperaments in impersonal organizations. These have given an ominous popularity to the term "maladjustment" and led to a great outburst against "organization men" by sociologists like David Riesman, William H. Whyte and Vance Packard.

The second is the gearing of educational systems to state needs. The more science and technology impose qualifications on postulants for the professions, so the less freedom seems to be available to them to build up batteries of autonomy that will sustain the postulants in maturity. Not a little of the modern fiction is concerned with the dilemma of the scientist faced with moral problems, and those who have not discovered for themselves the novels of C. P. Snow are advised to do so, and not least because Sir Charles himself has climbed the scholarship ladder of science. Another engineer novelist, Nevil Shute, has also explored the moral hinterland of technological advance, notably in *On the Beach*.

A third problem is to prevent the new educational institutions that are being so rapidly built all over the world succumbing to the sclerosis of organizational hardening ; to ensure that they nourish, not sterilize, the flower of genius. The subtle and evanescent qualities impelling scientific advance need play (in the engineering sense) in any bureaucratic machine. Such institutions

provide a stimulus to personality development hitherto afforded by distributors formerly catering for the elite.

A fourth problem is to provide a moral substitute for wars. As William James discovered, this is hard to find, but since his time we have learned a little more. To-day we must provide a substitute for " hot wars " in " cold wars " against want and disease. The last and deepest problem is to contain, or to come to terms with, the philosophy generated in the heyday of Britain's industrial hegemony by Karl Marx, which is based on a philosophy of technological development which Arnold Toynbee has described as the last great Christian heresy. Its early fathers, Lenin and Mao Tse-Tung, have elevated the scientist into a priestly role. Its contemporary neophytes are making few, if any, hard and fast dogmas in the fields of mathematics, physics, engineering and chemistry, and are integrating biology, history and literature to secure the better understanding and comprehension of these.

All these problems underline the changing functions of the schools and colleges. Such diverse observers as Coleridge, Benjamin Disraeli and Lewis Mumford have noted that teachers are becoming (indeed have become) the new sacerdotal class of our society. More than any others they can humanize the capacity-catching machine, nourish the love of creation and adventure, cultivate the moral sensibilities and awaken the latent autonomy in each student. As Lewis Mumford has wisely written: " We can no more continue to live in the world of the machine than we could live successfully on the barren surface of the moon. Man is at last in a position to transcend the machine and to create a new biological and social environment, in which the highest possibilities of human existence will be realized, not for the strong and lucky alive, but for all co-operating and understanding groups, associations and communities ". Of these groups, the engineers are a growing body.

Compared to the close association of engineers and technologists both in the U.S.S.R. and the U.S.A., Britain offers a sharp contrast. There is nothing obviously analogous in Britain to the American Society for Promoting Engineering Education (founded in 1893), or the American Engineering Council (founded in 1920 and abandoned in 1938), nor the Engineers' Council for Professional Development (founded in 1932), nor the National Society of Professional Engineers (founded in 1934). Yet there have been movements to form such organizations.

The British Science Guild for instance, during its existence from 1905 to 1936, the Engineers' Joint Council (formed in 1922), and the Engineers' Guild (formed in 1938) have all in their way expressed the engineers' claim to exist as a professional group. The one attempt to found a General Engineering Council (analogous to the General Medical Council) never got past a first reading in the House of Commons on 29th April 1926. The General Strike, as much as anything, killed it.

The " engineering point of view " in British public affairs is exhaled partly through the Parliamentary and Scientific Committee (a loosely knit body constituted in 1932), partly through the Royal Society, and partly through the four senior societies of the Civil, Mechanical, Electrical, and Chemical Engineers. These, linked with other professional associations, institutions, and corporate groups in a loose but effective manner and with local, regional, national and international associations and authorities, ventilate matters with the loose informality possible in these islands. Their multiple memberships, informed by the regular issue of journals, and convened regularly, are a guarantee that a healthy dialectic is sustained and that they can have their say, if not their way. Sparking progress, ventilating problems and maintaining standards, they embody the vigorous group life of a modern state. They can act, at times, as pressure groups when and where a national issue demands an expression of opinion.

THE SPATIO-TECHNIC PHASE OF OUR CULTURE

Twenty-five years ago, Lewis Mumford classified four phases of technological growth : the eotechnic, paleotechnic, neotechnic and biotechnic. As outlined in *Technics and Civilization* (1934) and *The Culture of Cities* (1938), the eotechnic was based on wind, water and wood ; the paleotechnic on coal and iron ; the neotechnic on electricity, steel and light alloys, and the biotechnic on the application of science to life processes (insecticides, disinfectants, weed killers, chemotherapeutics, fertilizers and contraceptives) to control man's own evolutionary processes. He saw these periods as emergent or recessive in particular parts of the world, and also did his best to make his contemporaries aware of the environmental mesh through which they were evolving.

To Mumford's four phases we should now add a fifth: the spatiotechnic, the emergent phase of our time. To-day we live in an age when Moscow is less than four hours plane journey from London and the earth itself is circled by an increasing number of man-made satellites which are going to enable us to predict the weather, investigate the solar system, and still further shrink the world to the significant dimensions of an early twentieth century or a nineteenth century nation. The organizations that now acquire significance are the international ones. The international Power Conference (now twenty-five years old) and the International Atomic Energy Agency (the four-year-old world bank for fissile material and scrutineer of health hazards) are but two of many international groups buttressing the work of the United Nations Organization. Aggregations of states based on planning independent of the United Nations have also been established in Western Europe (like the Coal-Steel Community, the Common Market and Euratom) ; in the Near East (like the Baghdad Pact) ; and the Far East (like the Colombo Plan). All three involve technical assistance from advanced Western nations in the production of power for the service of man. These three supra-national groups comprise in all some twenty-one countries : in the first Belgium, France, West Germany, Italy, Luxembourg and the Netherlands ; in the second Iraq, Pakistan, Iran and Turkey ; and India, Pakistan, Ceylon, Burma, Thailand, South Vietnam, Laos, Cambodia, the Philippines, Indonesia and Japan respectively.

THE ENGINEER IN SOCIETY

As the provider of energy slaves, the engineer is increasingly important in society. Behind his provision are the scientists. The artistry of a bridge builder is obvious to the naked eye, but the activities of the chemical

engineer are not, until his products are bottled, batched or baled. Both profoundly affect the evolution of mankind. One enables physical barriers to be crossed, the other helps biological ones to be circumvented.

Both are parts of a living development and are separate only in so far as orderly minds must separate in order to comprehend them. The visible achievements of Telford, Paxton, Labrouste, Contamin and Eiffel have been increasingly affected by the invisible mathematicians and scientists who have provided them with the formulae and materials they needed. And materials, scientifically tested, have become more important still in the hands of their successors—Hennibique, Freyssinet, Gropius, Nervi and Candela. To-day's " frozen music " is, more often than not, written, scored and orchestrated in places like the Illinois Institute of Technology. There, since 1938, Mies van der Rohe has built and taught others to build the great structures of to-day : the General Motors Technical Centre at Detroit or the Kresge Auditorium at the Massachusetts Institute of Technology.

Engineers and technologists contribute something more than their structures to society. Without them science would probably degenerate into a series of casuistic exercises. Their strategic position between the endless frontiers of new knowledge on the one hand, and the equipment proved by success on the other, enable them to act as the most effective revolutionists of our time. So that misunderstood sect, the technocrats, might find that the prophecies of their messiah Veblen are being fulfilled and that the engineers are really becoming the élite of our society.

The professional politicians and political theorists have already found engineers among their ranks. Herbert Hoover was the first professional engineer to become President of the United States ; whilst Georges Sorel, after twenty-five years as an engineer, elaborated his syndicalist doctrines which, as much as any others, have influenced political thinking in Europe in this century. In the field of pure political theory, Carl Schorlemmer was described by Engels as " After Marx . . . undoubtedly the most eminent man in the European Socialist Party " whilst on the other hand Salvador de Madariaga, originally trained as an engineer, was one of the most articulate spokesmen for the Liberal tradition in the early half of the twentieth century.

Philosophy, the very core of a liberal education, has been consistently affected since the enthusiastic polytechnicians of nineteenth century France elaborated positivism. Perhaps the most recent and notable example of the engineer-philosopher at large in Britain was Ludwig Wittgenstein, who after graduating at the Technische Hochschule at Charlottenburg, Berlin, in 1908, came to Manchester to work as a research student in the engineering laboratory of the University on reaction jets at the tips of propeller blades. He became so interested in the design of propellers that he concentrated on their mathematical theory. Eventually, on returning to Austria in 1914, he found himself in the army and concentrated on mathematics and philosophy. When he died in 1951 he had held the professorship of philosophy at Cambridge and was the author of the *Tractatus Logico-Philosophicus*. These " highly synco-, pated pipings ", as another philosopher called them have proved to be most influential in the very institutions, like Oxford and Cambridge, which have exalted a training in words rather than things. For Wittgenstein taught that philosophy is an activity of making clear to people what they can and cannot say. We need more philosophers to-day with a training like Wittgenstein's. Perhaps you gentlemen could do something about it.

Bulletin of The Institute of Physics and The Physical Society

Polytechnical Education in the U.S.S.R.

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NATIONAL systems of education are neither simple to establish nor subsequently easy to modify. Since the problems they are designed to solve and the criteria by which their quality is judged tend to change more rapidly than they do, the schools are rarely, if ever, perfect. The general reason for this state of affairs is clear. Educators are as much the transmitters of a previous culture as they are the fashioners of a future one. Traditions die hard and are constantly re-enforced by the schools. Consequently there is always likely to exist between an educational system and other aspects of a society what William Ogburn called " social lag ". Another general point should be noted. Some social changes are irreversible. Policy decisions in education set in motion a sequence of events which cannot be reversed simply by a change of law. Multiple consequences flow from such decisions and one of the perplexing problems for educators to solve is to devise methods of anticipating, or predicting, not only the short-term benefits of any policy but also its long-term political, economic, and social results. Parenthetically, in spite of the inherent difficulties of predicting in the social sciences most educators see the achievement of distant aims as the justification for the policy they advocate. These two considerations, social lag and uncertain predictability, make it difficult for the architects of a school system to use it successfully as the most important instrument of radical social reform. Certain objectives might be gained, but in the achievement of them other problems arise.

To these general hypotheses the Soviet educational system seems to be no exception. According to Krupskaya, " Lenin attached particular attention to the upbringing of the growing generation. He regarded the school as an instrument for re-educating the entire growing generation in the spirit of communism ". (*On Education*, Moscow Foreign Languages Publishing, 1957, p. 192). Great things have undoubtedly been achieved since the revolution. A successful attack has been made on widespread illiteracy. A vast network of schools has been built up making compulsory education virtually universal for at least seven years. Institutions of higher education have turned out in vast numbers highly trained specialists of every description, and particularly scientists and technologists. To some extent Lenin's hopes have undoubtedly been fulfilled. Yet the Soviet leaders are not satisfied.

Mr. Kruschchev has stated the problem succinctly. " Our ten-year schools, however," he said, " are at present not accomplishing the task of training the young people for life, and are only training them for entering college ". (N. S. Kruschchev, *Memorandum on Proposals for the reform of Education*, Soviet Booklet No. 42, October 1958. Published by *Soviet News*, p. 4). In other countries, too, this criticism of the schools of to-day is not uncommon. But Kruschchev's remarks should be analysed within the Soviet context. Educational policy there has not been solely determined by ideology. At first the theory that all truly educative processes have their origin in productive labour or in manual work tended to influence policy. Consequently in the twenties there was an underestimation of intellectual work. In the thirties and particularly after 1935 there was a reversal of policy. As part of the drive to catch up with and overtake the capitalist countries great attention was given to intellectual training with the object of building up cadres of specialists. Policy in the immediate post-war decade did little to redress the balance. The successes attributed to this educational policy have been widely acclaimed. It is apparent that in many respects it differed little from the continental European traditions, but economic incentives made it possible to attract to science and technology large numbers of the most gifted students. Success has brought its own difficulties which were brought into sharp focus by Mr. Kruschchev in the memorandum referred to above. A law designed to strengthen the ties of the school with life was passed in December 1958 but the problems it sets out to solve are still very much at the forefront of pedagogical discussion in the Soviet Union.

One aspect of the malfunctioning of the system is that an increasing number of secondary school graduates are unable to enter directly into institutions of higher learning. The secondary schools have overproduced intellectuals whose ambitions lie in the direction of further education. Many students leaving secondary schools, in 1957 about two in every three, entered industry, commerce or agriculture and were often unprepared both psychologically and technically to do so. The principal reason given by Soviet educators for this state of affairs is that pre-revolutionary educational traditions have been perpetuated in the schools. The theory and practice of Tzarist education was basically European modified by a greater emphasis on science and with less attention paid to the classical languages than in other European countries. One important element in these traditions was, and continues to be, based on the distinction Aristotle made between the type of education appropriate to the free man and that suited to the artisan. This distinction led to a dichotomy being made between mental and manual work. Knowledge for its own sake was prized, consequently the content of the curriculum was abstract ; theory was often divorced from its practical applications. Moreover, in the European tradition, methods of teaching were didactic and formal. In their own schools it is these characteristics which Soviet writers now find unsatisfactory. And indeed it is not surprising. A brief visit to Soviet schools

reveals the extent to which these criticisms are founded upon fact.

The proposals in the new law and those now being debated should also be examined within the context of Soviet ideology. Of course it is perfectly possible to emphasize the economic benefits of the solutions proposed, namely that most young people will in future enter special training for industry and agriculture after eight years at school instead of after ten years as was the intention previously. But there is also a genuine educational aspect which since it involves an attempt radically to change the attitudes of young people is fundamentally moral in purpose. Because in communist theory economic activities are considered of vital significance, man's attitude toward work constitutes an important basis of morality. Since life itself centres round it the dignity and importance of work are stressed. In a truly communist society, moreover, the most efficient use of social and economic resources is an important aim, and can be achieved through the sound organization of labour without enforcement. The task of education then is to develop each individual to the full extent of his abilities in order that he might accept his responsibilities as a Soviet citizen and promote the growth of a communist society. Fundamental to the achievement of this aim is the inculcation in pupils of the correct attitudes towards work, of a knowledge of production methods, and of technical skills based upon theoretical principles. In practice, instruction has to be combined with productive labour or with socially useful work.

This particular solution to an old dilemma has a long history. Soviet educators acknowledge Thomas More, John Bellers, Comenius, Rousseau, and Pestalozzi as well as the "great Utopian socialists", F. Fourier and R. Owen, as having anticipated in their writings some of the ideas advocated by Marx and Lenin. In general the aim is to abolish the deforming divorce between mental and manual work or, in educational terms, to bridge the gap between general education and vocational training.

According to communist theory polytechnical education provides this bridge. The concept itself is still in process of more precise and meaningful formulation but some idea of what is involved in polytechnical education might be gained from the following statement: "Polytechnical education includes the children's learning about the major branches of the economy, work in industry, the receiving of practical training and often definite industrial skills. In such subjects as physics, chemistry, mathematics, geography, natural sciences and mechanical drawing they acquire a solid foundation of the basic knowledge needed in each field of industry and agriculture; while working in the school shops, and laboratories and training at the factory shops and in the collective and State farm fields, they learn to apply theory to practice". (*U.S.S.R. To-day*, p. 213, 214.) The basis of a sound "liberal" education, polytechnical education will also help to raise production. The two objectives are not, of course, unrelated. Industrial techniques are in process of rapid transition. Many Soviet writers are aware that automation will create radically new conditions in which workers will be required to perform different functions and will need different qualifications and knowledge from those demanded of them previously. They will for example need to have not only the skills of a trained technician but will also need to have a wide knowledge of the principles of science and technology as well as an acquaintance with all aspects of modern production. As I. A. Kairov has put it, "engine drivers will become genuine locomotive engineers". Moreover, automation will result in a much shorter working day. Soviet educators see as one of their new tasks the preparation of young people who will be able to enjoy their leisure time. Consequently modern education should promote the all-round development of an individual by paying attention to his moral, physical, intellectual and aesthetic growth.

As far as the nature of the problem is concerned there is general agreement among the Soviet writers I have been able to consult in translation. The general solution, namely that instruction should be combined with productive labour and socially useful work is also acclaimed. Differences of opinion turn on the more precise theories of how best to achieve this union. The debates are vigorous and indeed the arguments of the protagonists have a familiar ring to educationalists in Western Europe and North America. Nevertheless, major reforms have already been enacted in the law on strengthening the ties between school and life and on further developing the public education system in the U.S.S.R. The principal changes are in the structure of the school system and in the curriculum. The period of compulsory education will be extended from seven to eight years. A complete secondary education will comprise ten years of study slowly to be increased to eleven. Within the system of education between the ninth and eleventh years radical changes have been proposed. Students leaving the eight year school will proceed to one of three types of school to complete their secondary education. A considerable number, some estimates suggest about 50% of the age group, will go to schools for workers or collective farmers. These schools will be run on part-time evening or shift basis. Students whilst actively at work in factory or on farm will be granted time to complete their general education, to receive polytechnical education, and to improve their technical qualifications. In these schools, obviously, the links between work and instruction should be very close. In the second type of school students will prepare for some branch of the national economy. These schools like the technical colleges and trade schools under the previous system will co-operate very closely with local industries. Students will spend between a third and a half of their time in school, the rest will be spent in specially organized training sections and shops in local enterprises. In rural areas according to the seasons there will be alternating periods of study and participation in farm work. In principle, the work of these schools will be determined very much by local conditions. Undoubtedly they will provide local industries with highly skilled technicians and craftsmen. In the third type of school more emphasis will be given to general education, and technical or professional training. Many students from these schools are likely, it seems, to proceed after three years of study to institutions of higher education. More boarding schools are to be established, if

parents desire them. It is felt that in the controlled environment of the boarding school the wider aims of the new law might be more easily achieved. As far as one can judge, those boarding schools which already exist enrol children from somewhat disadvantaged homes rather than from the homes of the upper middle classes.

Certain changes in the curriculum have also been made. More socially useful work has been introduced into the general curriculum at the expense of subjects like Russian language and literature, geography and history. During the first four years twice as many hours as previously will be devoted to socially useful work. This means an allocation of about two periods a week to it. In the senior classes of the ten (soon to become eleven) year school a third of the school week is to be given over to work experiences of one kind or another. The precise organization of socially useful work as part of the curriculum will depend on local conditions but contact with factories or nearby farms will be established. In addition extra-curricular activities, hobby circles, mass media, school visits and so on are to be used to illustrate production methods, give students some knowledge of working conditions and make it possible for them to relate theory more effectively to practice. It is also generally agreed that work in production before entering an institution of higher education would benefit all young persons. Indeed Mr. Kruschchev stated that in his view " all pupils, without exception, should be drawn into work benefiting to society at industrial establishments, collective farms, etc., after they have finished seven or eight forms at school ". (*Proposals to Reform Soviet Education* memorandum by N. S. Kruschchev, Soviet Booklet No. 42, October 1958. Published by *Soviet News op cit.*). Understandably, the danger of underproducing young intellectuals has been recognized and the new law states that each Union Republic shall " wherever necessary, retain a certain number of the existing secondary schools throughout the transition period " thus avoiding any interruption in the supply of young specialists. (Article 7 of the Law in, for example, K. Galkin, *The Training of Scientists in the Soviet Union.* (Moscow 1959)).

Legislation can bring about these organizational changes in the structure and curriculum of the schools. But the problem as seen by Soviet educators is also one of changing the attitudes of students and teachers so that the whole approach to education will be modified. And this task is more difficult. It is apparent that there is no unanimity of opinion on many questions. The debates about methods of teaching and the content of courses are quite familiar to educators outside the U.S.S.R. Fears well known to them are expressed. Different approaches to content and the methods of teaching polytechnical education are advanced. Two methods previously attempted seem to be rejected. The selection of subject matter solely in accordance with the needs of productive labour is no longer acceptable ; nor is an approach which was subsequently advocated before the return to intellectualism occurred. In this scheme, reminiscent of the project method, educational subject matter was centred round the numerous working activities of people. The school was to be organized like life itself. Education was to be a single indissoluble process achieved through complex programmes in which the laws of nature, labour and society were to be studied and the links between them established. Criticisms have been made of both these earlier attempts to find a basic principle on which courses of study can be based. The use of labour as an organizing principle, it is argued, breaks either the logic of school subjects or the ordered sequences of labour processes. Moreover it excludes from the curriculum some subjects unrelated to labour which are nevertheless important in the general education of children. The chief criticism of the " complex " approach seems to be that the links established are artificial. Present-day discussion turns on the practical possibilities of organizing courses of study so that organic connections are made between instruction and work, so that neither the logic of the school subjects nor the regular sequences of industrial routines are broken. Some writers advocate parallel courses, others think that this is often ineffective if theory is to be related to practice, and if more than mental knowledge and manual skills are to be acquired. A further complication is the fact that there is also a debate going on about whether or not the psychological needs and capacities of children should form the principle of organizing courses of instruction rather than either the logic of the subject matter or the industrial skills. Some writers, indeed, recognize the claims of all three principles of selecting data and advocate a multilateral approach. As for methods of teaching, not only have the principles of the natural sciences to be taught but also the objective links between these subjects and technological subjects have to be made known. The familiar principle of " integrating " subjects by relating together data from different subject fields is also discussed. In teaching any subject, in fact, an attempt should be made to reveal the direct link between scientific principles and industrial practice. In these ways attention to industrial production will permeate the teaching of every subject in the school curriculum.

Many of the theoretical concepts are still in the process of being formulated. Experiments are taking place throughout the Soviet Union in an attempt to discover practical means of combining instruction and socially useful work. What is of significance and interest in all this, is the fact that Soviet educators far from being satisfied with the results already achieved by their schools are disturbed about the quality of education. They have pin-pointed for discussion a problem which is of vital significance in highly industrialized societies to-day. In all of them the demands of industry are such that many highly qualified scientists and technologists are required. The quantitative aspect of the demand created during the period of transition from nineteenth century modes of production to the automatic factories of the late twentieth century is clear, and has perhaps been recognized by most governments. Two problems, indeed closely related, remain for serious consideration, however. The first concerns the type of training future scientific and technological specialists should have if they are to function effectively in industry. The second concerns the possibilities of reconciling within an educational programme the inculcation of vocational skills and knowledge (and automation will demand not only

advanced scientific and technological qualifications of its operators but also quite different social and managerial skills) and the inculcation of skills, attitudes, values, and knowledge which will enable an individual to develop himself fully as a person and also fulfil his other responsibilities as a citizen. Stated in another way, the fundamental problem is one of devising a form of "liberal" education appropriate to the twentieth century. The task is a dual one. First, it demands that concepts of "liberal" education should be scrutinized and re-formulated. Secondly, it involves major modifications to educational practices. Because European countries and the U.S.A. share a common tradition some aspects of the problem are found everywhere. Differentiating features make the specific problems of reform in each country unique. For example, most national educational systems are the product of the last century. During the latter half of it, debate centred on the place vocational studies should occupy in education. The demands of commerce and industry for ready trained young people had to be weighed against the growing need for a politically responsible electorate. In the event national policies differed widely. Many continental governments, with or without private support, set up an extensive system of vocational schools and thus institutionalized the dichotomy between "liberal" studies and vocational training. In England this policy did not prevail, and emphasis was (and is still) given to the provision of a general or "liberal" education for all pupils. The national differences revealed by institutional arrangements are paralleled by concepts of what constitutes a sound general or "liberal" education. The English educator still gives high priority to the development of a sound moral character through the whole atmosphere of the school, extra curricular activities and the academic study of rather a small number of subjects. The French educator is inclined to emphasize the importance of clear, logical thinking best developed through mathematics, the correct use of French and the study of classical languages. The latter form the core of the German *Allgemienbildung*, a concept which perhaps derives from the romantic and Hegelian traditions and stresses the desirability of enabling individuals to penetrate the surface of appearances to the essential nature of men and things. In every case, however, esteem for the classical languages checked the development of science and technology as school subjects. The classical tradition was decisively broken about the turn of the century in the U.S.A. where educators have long given high priority to the democratic role of general education. Now the Soviet educators have given to their idea of a satisfactory "liberal" education the word polytechnical education.

The questions which worried nineteenth century educational reformers rise in an exaggerated form to-day. It is hardly possible now as it was then, to decide that future administrators should have a basically classical education and future workers should be trained for a particular job. Nor is it realistic to suppose that the English policy of providing a "liberal" education for all based upon the arts subjects is adequate. The policy makers of to-day cannot safely ignore the claims of science and technology because they are vital to economic progress. Industrial processes make it absolutely necessary that technical, production, managerial, and commercial personnel should be well grounded in these subjects. On the other hand, the political and moral issues of the day demand that responsible citizens in their attempts to reach decisions should be able to weigh up the relevant scientific evidence. Without this ability they can hardly be safe from demagoguery. On both counts, the economic-industrial and the political-social, science and technology should be essential ingredients of the core of any "liberal" education. As scientific information proliferates at an alarming rate the proportion of time necessarily required by the schools to make it known will increase. The danger that the sciences and technologies might be taught without regard to the contribution they should play in a "liberal" education has often been stated ; a realistic solution does not appear to lie in maintaining the balance of time between the sciences and the arts subjects, but rather in using profitably an increased proportion of time allocated to science.

The situation in the Soviet Union would appear to be of this kind. Over the years the prestige of science and technology has been built up tremendously. For individuals the economic returns after studying these subjects are high. The curriculum of the schools, after the fourth class, is heavily biassed towards scientific subjects, more than half the time-allocation being given over to them. In general the methods of teaching science have been didactic and formal, the content of the courses generally speaking abstract. Intellectualism in science education has helped to produce a crop of extremely competent specialists and research workers. The problem is not really to raise the prestige of science or to win for it a rightful place in the curriculum —tradition, Marxian theory and economic necessity have combined to achieve these things. Rather is it a question of re-orienting the whole of formal education so that less weight will be given to intellectualism and more weight will be given to what, in English terms, might be called character training or moral education. Specifically the present proposals for reform in the U.S.S.R. might usefully be interpreted as an attempt to "liberalize" the teaching of science and technology.

There is little evidence to suggest that Soviet educators are going to be able to throw off overnight the shackles of an earlier European tradition. In spite of the spate of discussion about polytechnical education theories on which the future of the reform movement ultimately depends have not been fully worked out yet. Some prominent Soviet writers point to the lack of research and theoretical investigation in the field of polytechnical education in spite of the many experiments going on throughout the country. Not everybody, moreover, is entirely convinced. Any exclusive reliance on productive work as the starting point of all true education will be resisted. Already concern has been shown for the humanities. Not all work experiences are recognized as educative. Neither industrialists nor the guardians of academic standards seem, as yet, fully convinced of the value of students spending a considerable proportion of their time in factories or on farms. The debates about methods of implementing the new law are likely to be prolonged. Out of them, no doubt, new approaches

to education might emerge. It seems inconceivable, however, that the task of finding a better balance between intellectual and manual work will be dismissed as unimportant and therefore neglected. It might well be that this problem occupies the centre of the stage in the U.S.S.R. because it is more serious there than in some non-communist countries. Evaluations of this kind are necessarily tentative, but it would be a serious mistake to judge Soviet education solely on its demonstrated ability to turn out large numbers of well trained specialists. Soviet leaders no longer do so. They recognize that it is as important to prepare young people for life as to train them for college. Yet intellectualism in the Soviet schools will not easily be tempered by the introduction of socially useful work to produce a flexible system of education meeting multiple purposes. If we are to learn from Soviet experience we would do well to study some of the tasks of reform now facing educators there.

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Mrs. P. G. Dunsmuir
Mr. A. S. Edmondson
Mr. M. Edmundson
Dr. A. von Engel
Dr. J. S. Forrest
Miss A. D. Forster-Brown
Mr. E. W. Foster
Mr. M. Gardiner
Mr. F. W. J. Garton
Dr. A. N. Gent
Dr. A. W. Gillies
Mr. P. N. Goble
Dr. A. J. Goss
Mr. J. A. Greenacre
Mr. T. F. Gulvin
Mr. W. J. Gunning
Mr. G. W. Hamstead
Mr. B. F. Hann
Mr. R. I. Harris
Dr. A. Harvey
Mr. J. W. Head
Dr. S. J. Hewitt
Mr. R. J. Hill
Mr. L. Holland
Dr. J. E. Houldin
Mr. I. G. Moelwyn Hughes
Mr. F. I. Hurley
Professor D. J. E. Ingram
Mr. R. E. James
Dr. A. Jenkins
Mr. E. Kahan
Dr. G. Klein
Dr. B. G. Knowles
Dr. J. R. A. Lakey
Mr. A. Langridge
Mr. A. B. Lewis
Mr. F. P. Likely
Mr. S. Lucas
Captain W. G. McDougall
Dr. A. McNair
Mr. R. C. McVickers
Dr. G. Morris
Professor T. E. Nevin
Dr. G. B. F. Niblett
Dr. W. M. Nicol
Dr. B. E. Noltingk
Dr. U. Öpik
Mr. R. M. Organ
Mr. W. P. Osmond
Mr. J. Overy
Mr. W. S. Paige
Mr. G. J. Parish
Dr. A. F. Pearce
Mr. D. W. Petchey
Mr. B. G. Phillips
Dr. T. G. Pickavance
Mr. A. C. Ponder
Mr. J. S. Preston
Mr. G. C. Pullum
Mr. T. I. Putner
Dr. E. R. Rae
Mr. J. D. Rands
Mr. H. B. Renny
Mr. E. A. Richards
Dr. G. L. Rogers
Miss J. M. Rooke
Mr. P. B. Round
Mr. V. W. Rowlands
Mr. E. A. Ryder
Mr. R. V. Ryder
Dr. A. J. Salmon
Dr. N. H. Saunders
Dr. R. Schnurmann
Mr. B. W. Sharpe
Mr. J. W. Sharpe
Mr. J. S. Sivyer
Mr. A. Skertchly
Mr. D. L. N. Sly
Mr. S. E. F. Smallwood
Mr. E. M. Somekh
Mr. G. M. Somerville
Mr. J. G. Speight
Mr. J. B. Spence
Mr. R. H. Spiller
Mr. L. K. Street
Mr. R. Teale
Mr. J. M. Titman
Mr. H. C. Tresise
Mr. W. H. Tucker
Mr. A. E. Turner
Dr. E. V. Vernon
Mr. R. A. Waldron
Mr. G. S. Walker
Dr. W. G. Wearmouth
Mr. A. Weinmann
Dr. R. W. Whitworth
Dr. W. S. G. Williams
Mr. G. E. Wilson
Mr. J. B. Woodward
Dr. C. E. Wynn-Williams

(*b*) From firms

American Machine & Foundry Co.
Baird & Tatlock (London) Ltd.
Dudley Drop Forging Co. Ltd.
Electrothermal Engineering Ltd.
Englehard Industries Ltd.
Fibreglass Ltd.
Hilger & Watts Ltd.
I.B.M. United Kingdom Ltd.
I.B.M. World Trade Laboratories (Great Britain) Ltd.
George Kent Ltd.
Mitchell Engineering Ltd.
Mobil Oil Company Ltd.
Mycalex & T.I.M. Ltd.
R. Y. Pickering & Co. Ltd.
H. Tinsley & Co. Ltd.
20th Century Electronics Ltd.

The total received or promised by February 23, 1961 (including those previously announced) was :

	£
Gross value of industrial firms' covenants over seven years (including tax recoverable)	98,212
Single donations from firms	7,260
Total from Industry ...	105,472
Gross value of 212 members' covenants over seven years (including tax recoverable)	4,714
Single donations (236) from members	654
Total from members ...	5,368
GRAND TOTAL at February 23, 1961	£110,840

The members' covenanted subscriptions are for amounts distributed as follows:

Net annual contribution of up to one guinea	134
Net annual contribution of more than one guinea but less than five guineas	61
Net annual contribution of five guineas or more	17

The Council is most grateful to all those who have responded so generously to this appeal and hopes that those who have not yet done so will indicate their support of the scientific and educational work which it is endeavouring to carry out by subscribing to the Physics Trust Fund.

X-RAY ANALYSIS GROUP

The Spring Conference of the Group

will be held in the

University of Glasgow

on April 6 and 7, 1961

on

"The crystal structures of organic compounds"

An evening discourse on "Philosophers and Kings" will be given at 8.15 p.m. on Thursday, April 16, by Professor R. V. Jones, C.B., C.B.E., F.Inst.P.

Programs and application forms are available from the Administration Assistant of the Institute and Society

STRESS ANALYSIS GROUP

The fifteenth Annual Conference of the Group

will be held at the

Department of Physics
The University of Southampton

from 24-27 April, 1961

on

The mechanics of rupture

Registration is necessary and program and application forms are available from the Administration Assistant of the Institute and Society.

Notes and News

Dr. C. V. Drysdale

Although it is not the practice to include obituary notices in the *Bulletin*, the death of Dr. C. V. Drysdale at the age of 86 cannot be allowed to pass without referring to his many services to The Institute of Physics and The Physical Society and its predecessors and to the *Journal of Scientific Instruments*. Drysdale was elected a Fellow of The Physical Society in 1898 and served on its Council from 1936-1939. He took an active part in the work of the Optical Society and was its President in 1903-1904. That Society amalgamated with The Physical Society in 1932. Drysdale received the Duddell Medal of The Physical Society in 1935. He was a Founder Fellow of The Institute of Physics and served as a member of the Board of the Institute 1924-25 and again in 1932-36 as one of its Vice-Presidents. He was appointed a member of the original advisory committee of the *Journal of Scientific Instruments* in 1923 and became its Editor on a part-time basis in 1925, a post which he held with distinction until the pressure of work forced him to resign in 1928. He was, however, good enough then to accept appointment as the Honorary Adviser in which capacity he continued to serve until 1948. Those who had the privilege of working with him will always remember the ready help he would give to those seeking his advice and his very profound knowledge and interest in scientific instruments and apparatus.

It is on the work and service of such people as Drysdale that the present success and many activities of the Institute and Society are based and it is well for some of the younger members to be reminded of the work of these pioneering gentlemen when physics and its several branches were almost unknown outside a few academic centres.

First A.R.M.

The first Annual Representative Meeting of the amalgamated Institute and Society will be held on May 3 next at headquarters. This, in accordance with Article 94, consists of the Chairmen and Honorary Secretaries of the Branches and Groups, the Past-Presidents of the Institute and Society both before and after amalgamation and " not more than ten other members appointed by the Council " together with the Honorary Officers of the Institute and Society and all other members of the Council. The present membership of this body is 76 and the Council has therefore decided not to appoint any other members to it yet.

The object of the Representative Meeting is to keep the Council in close touch with the members and to ensure that the present Council has the advantage of the advice and guidance of those that have served as its Presidents in the past.

Members who have constructive suggestions to make, which they would like this meeting to consider should send their proposals to their local Branch Honorary Secretary or to the Group Honorary Secretary concerned who will bring the matter before the Branch or Group Committees which will instruct their Officers on its presentation at the A.R.M. Branch and Group Officers have been asked to submit any matters they wish to raise by April 7 next ; their names and addresses will be found on the inside back cover of this *Bulletin*.

Nominations for Awards

The Awards Committee will be meeting shortly to make its recommendations to Council for the 1962 Awards. Members wishing to propose names for consideration for any of the Awards within the gift of the Institute and Society should submit them to the Secretary not later than April 28 next, together with a citation of about 100 words of the persons nominated. All of these Awards are made without restriction as to nationality or membership of the Institute and Society.

The Awards to be considered are the Guthrie Lecture, The Thomas Young Oration, the Rutherford Memorial Lecture, the Charles Chree Medal and Prize, the Duddell Medal and the Charles Vernon Boys' Prize. Details of the terms and conditions of the Awards are given in a booklet which will be sent by the Secretary on request.

Physical Science Study Committee course

The school physics course which has been worked out in detail by the American Physical Science Study Committee has aroused great interest among a number of school teachers, university lecturers and others in this country. The textbook of the course, now available here, is reviewed on page 67 of this *Bulletin*. The Institute and Society is associated with steps that are being taken to consider the adaptation of this course to meet European conditions and needs.

1961 Atoms for Peace Award

On April 6 the 1961 Atoms for Peace Award will be presented to the President, Sir John Cockcroft, at the Massachusetts Institute of Technology. Sir John will receive the award—a gold medal and $75,000—for his contributions to the peaceful uses of atomic energy "from the first demonstrations that this energy can be released by man's ingenuity and skill to the direction of the development of full-scale nuclear-powered generating stations supplying electricity to England ".

The Atoms for Peace Award, established as a memorial to Henry Ford and his son Edsel, is granted solely on the basis of the merit of the contribution to the peaceful uses of atomic energy, wherever found in the world and without regard for nationality or politics. Earlier recipients have been : 1957—Niels Bohr of Denmark; 1958—George C. de Hevesy of Sweden ; 1959—Leo Szilard and Eugene P. Wigner of the United States ; 1960—Alvin M. Wienberg and Walter H. Zinn of the United States.

Payment of subscriptions

Members are reminded that annual subscriptions became due on January 1. The form that should accompany remittances was included in the January *Bulletin*; extra copies may be obtained from the Institute and Society if required.

Maxwell Colour Centenary

The now independent Colour Group in collaboration with the Institute and Society and the Intersociety Colour Council of the U.S.A. have arranged a three day conference for May 16-18 next to celebrate the centenary of Clerk Maxwell's demonstration of Trichromatic Colour Reproduction. The Conference will be held at the Royal Institution, where the original demonstration was given and at Imperial College. Application forms may be obtained from the Institute and Society.

Vacuum Science—International Congresses

The second International Congress of the International Organization for Vacuum Science and Technology (IOVST) will take place in Washington, D.C., from October 16-19 1961 in co-operation with the American Vacuum Society (AVS). IOVST will sponsor the Congress and the Exhibition and AVS will sponsor the technical sessions and act as host to the Congress.

Details will later be available from the Institute and Society.

An International Congress on The Techniques and Applications of Vacuum, will take place in Paris from June 20-24 1961 and is being organized by la Société Française des Ingénieurs et Techniciens du Vide. The sessions are : (i) Fundamentals of vacuum technology, (ii) General techniques, (iii) Ultra-vacuum, (iv) Vacuum metallurgy, (v) Miscellaneous applications. Further details may be obtained from Madame J. Mainier, Secretariat Administratif, 147 A., Boulevard de Strasbourg, Nogent, Marne-Seine, France.

Symposium on Thin Metallic Layers

A Symposium on the electrical and magnetic properties of thin metallic layers, sponsored by the International Union of Pure and Applied Physics and by the Flemish Academy will be held in Louvain from October 9 to 12 1961. More information about this symposium can be obtained from Professor A. Van Itterbeek, Instituut voor Lage Temperaturen en Technische Fysica, Naamsestraat, 61, Leuven, Belgium.

International Conference on Magnetism

An International Conference on Magnetism to be sponsored by the International Union of Pure and Applied Physics and an International Symposium on Electron and Neutron Diffraction to be sponsored by the International Union of Crystallography will be held jointly in late September at the Kyoto Kaikan Assembly Centre, Kyoto, by invitation of the Science Council of Japan, the Physical Society of Japan and the Crystallographic Society of Japan.

The International Conference on Magnetism, constituting Part I of the joint meeting, will be one of the regular conferences on magnetism promoted by the Sub-Commission on Magnetism of the I.U.P.A.P.

The International Symposium on Electron and Neutron Diffraction is being supported by the Commission on Electron Diffraction of the I.U.C. and will deal with methods, phenomena and important applications of electron diffraction and neutron diffraction.

Part I and Part II will take place at the same time, but part of the programme will be so arranged as to amalgamate both Parts for papers on magnetic scattering of neutrons. The Conference will be open to scientists who are interested in the topic mentioned above.

Details of the Conference may be obtained from Professor T. Nagamiya (Chairman, Sub-Committee for Part I) or to Professor S. Miyake (Chairman, Sub-Committee for Part II), Organizing Committee of the International Conference on Magnetism and Crystallography, Science Council of Japan, Ueno Park, Tokyo, Japan.

Presentation of Awards

The Duddell medal awarded to Dr. J. B. Adams and the C. V. Boys prize awarded to Professor A. W. Merrison will be presented by Sir John Cockcroft at 4.30 p.m. on April 17 during the Nuclear Physics Conference which is being held in the Physics Department of the University of Birmingham. Immediately afterwards Dr. Adams will lecture on " The experimental use of the CERN proton synchrotron " and at 7.30 p.m. on April 18, Professor Merrison will give an address on " Counter techniques in high energy nuclear physics: rare decays of pi and mu-mesons ".

The presentation ceremony and both lectures are open to all Members, Students and Subscribers of the Institute and Society irrespective of whether they are attending the Conference or not. Tickets are not required.

EDUCATION GROUP

EASTER CONFERENCE ON

COMMUNICATION

Physics for the non-specialist

April 6 and 7 1961

at

47 Belgrave Square, S.W.1

Accommodation is limited. Enrolment forms are available from the Administration Assistant of the Institute and Society and should be returned as soon as possible.

Symposium on Electrical Contacts

The Institute and Society in collaboration with The Institution of Electrical Engineers is arranging a symposium on " Electrical contacts " to be held at Brunel College of Technology, London, on April 5 7, 1961.

Topics will include:

Electrical erosion and material transfer

Mechanical wear

Influence of surface films and contamination

Make-and-break contacts.

Sliding contacts

Semi-permanent contacts and connexions between metallic and non-metallic materials.

Major interest will be focused on contact resistance.

The Symposium is intended mainly for persons concerned with the design and improvement of contacts.

There will be a small informal exhibition.

Registration is necessary.

Programs and enrolment forms are available from The Secretary of the Institute and Society.

ELECTRON MICROSCOPY GROUP

The annual conference
of the Electron Microscopy Group
will be held at the
UNIVERSITY OF NOTTINGHAM
from July 10 to July 14, 1961

The main topics to be discussed are :

Electron Microscopes and Electron Optics—Past, present and future trends—Microscope devices and attachments.

Electron microscopy of thin films—including carbon, metal films, metal physics, magnetic domain theory, etc.

The theory and scope of electron diffraction methods.

Miscellaneous techniques and applications on electron microscopy.

The last day of the conference will be devoted to a symposium on " The physics of sectioning and the embedding process ".

Offers of papers should be sent, with short abstracts, to the Honorary Secretary of the Group, Dr. R. Reed, Department of Leather Industries, The University, Leeds, 2, not later than April 10, 1961.

It is intended to arrange an exhibition of apparatus and micrographs. Offers of exhibits should be sent to the Honorary Secretary.

Programs and enrolment forms will be available about mid-May from the Administration Assistant of the Institute and Society.

THE ANNUAL DINNER

Park Lane Hotel, Piccadilly, London

May 2, 1961

Tickets (exclusive of wines) are 45s. each; Graduates under the age of 25 and Students of the Institute and Society may have either one or two tickets at 30s. each.

Forms of application were circulated with the February *Bulletin*. Additional copies are available from the Secretary. Applications should be submitted as soon as possible and not later than April 12.

Reviews of Books

PHYSICS. (THE PHYSICAL SCIENCE STUDY COMMITTEE TEXTBOOK)

Boston: D. C. Heath and Company. London: George G. Harrap and Co. Ltd. Pp. viii + 656. Price 40s.

PHYSICAL SCIENCE STUDY COMMITTEE. LABORATORY GUIDE

Boston: D. C. Heath and Company. London: George G. Harrap and Co. Ltd. Pp. vii + 87. Price 10s.

The vanity of teaching (wrote George Savile some three centuries ago) doth often tempt a man to forget that he is a blockhead. Here is a book that tells us, obliquely yet firmly, what blockheads we have all been in the teaching of physics.

One of the most striking features of the scientific revolution in which we are living is the emergence of the natural philosopher as manager, as policy maker and even as statesman. Physics has come down from the ivory tower and into the market place. Massive achievements in the application of scientific ideas for useful purposes have established beyond argument the place of physics among the humanities—the branches of learning that no one can ignore if he is to play a responsible part in the affairs of the community.

The demand for instruction in physics grows apace; how do we meet it? Too often we meet the challenge with a dreary collection of archaic remnants, the tattered relics of a bygone age. Lord Rutherford used to say that there were two kinds of science—physics and stamp-collecting; a bright boy to-day might find it hard to tell the difference, so great is the gulf between the living, exciting reality and the bogus physics that flourishes in the schoolroom. Year after year our children bend their eager minds to the mysteries of the Wheatstone bridge, the Galilean telescope, the compound pendulum, the dip circle and all the other traditional favourites, studied with an earnestness out of proportion to their intrinsic importance or their relevance to the contemporary world.

It may be claimed that these exercises, worthless in themselves, are good training for the real stuff that comes along later. Of this argument A. N. Whitehead wrote: "I have no hesitation in denouncing it as one of the most fatal, erroneous and dangerous conceptions ever introduced into the theory of education. The mind is never passive; it is a perpetual activity, delicate, receptive, responsive to stimulus. You cannot postpone its life until you have sharpened it. Whatever interest attaches to your subject matter must be evoked here and now . . . whatever possibilities of mental life your teaching should impart must be exhibited here and now."

In the days when physics was studied for its own sake as an intellectual discipline, it mattered little whether the schools made a useful contribution. A century ago, Eton had 24 classics masters, eight for mathematics and three for everything else. Rutherford knew hardly any physics when he went to the university and J. J. Thomson had none.

In our own time, physics has become one of the principal means by which man uses the resources of nature to improve his earthly lot. Can the social, cultural and economic significance of this great contemporary movement be adequately conveyed to the young by pious study of the Victoriana with which textbooks and examination papers are still cluttered? Clearly it cannot—but how ought the job to be done? The new textbook produced by the Physical Science Study Committee provides a bold and attractive answer.

The object in teaching physics must be to present an honest, coherent and up-to-date image of the material world. This experience should be part of every person's education. Present-day educational systems in many countries, short of teachers, space and equipment, cannot cope with such a task. The available resources must therefore be used more efficiently.

These principles have guided the Physical Science Study Committee which was established in 1956 and has already spent more than $5,000,000 in the most exciting educational experiment of modern times. Led by Professor Jerrold R. Zacharias of the Massachusetts Institute of Technology, the committee began by defining a fresh syllabus for use in American high schools and writing a textbook to give it practical fulfilment. A one-year course embodying these ideas had been taken by more than 30,000 pupils in 650 schools by the end of the 1959-60 session. The textbook, revised in the light of this experience, is now available commercially for the first time. It gives an immediate impression of freshness and audacity. The text contains no padding, no digressions and offers no concessions to the intellectually under-privileged. The traditional barriers dividing the subject into compartments labelled mechanics, heat, light, sound and electricity have disappeared. The choice of topics is limited by ruthless concentration on the main purpose of the book. Statics, hydrostatics, calorimetry, photometry, elasticity and rotational dynamics are ignored or mentioned only in passing. The text includes no laws or definitions in bold type to be learnt. None of the numerical exercises can be solved merely by manipulating a formula. Most of the experiments described are of a kind that the student can do for himself. The whole emphasis of the course is on thinking, understanding and discussing rather than on mere learning. Students accustomed to a more authoritative approach, testing memory but not comprehension, will need considerable adjustment before their tongues and brains are properly loosened.

The first part of the course, representing about a quarter of the whole, deals with orders of magnitude, units, measurements and the basic ideas of the structure of matter. Discussion of counting, timing and distance measurement leads to the ideas of rectilinear motion, acceleration and vectors. Matter is next examined, with chapters on atomic structure and the nature of a gas. In the practical work for this part of the course, the student makes a microbalance (from simple components including a drinking straw, a needle and a

couple of microscope slides), estimates the dimensions of a molecule (from a monomolecular layer of oleic acid on a dish of water), and measures distances of the order of 1μ (with a simple optical micrometer). He also learns how to use a stroboscope and how to calibrate a rangefinder.

Two of the many exercises will serve to illustrate the demands made on the student a few weeks after his first introduction to physics:

1. The crewmen in a spaceship are discussing whether they could crack a walnut with a hammer. Man A says that hitting the walnut with the hammer would be no more effective than hitting it with a feather because the hammer is weightless out in space. B states that he found the mass of the hammer to be about one kilogram by comparing it with known masses on an equal arm balance: therefore, he could break the walnut as easily as back on earth. C maintains that the comparison with other masses proved nothing because out in space they too are weightless. Comment on the statements of the crewmen. Can they crack the walnut ?
2. Why are you sure there are more than 200 atoms in a spoonful of water ? Use the evidence of your senses—not some numbers or sizes someone else tells you.

The text and laboratory programme are reinforced by films (not yet available in Britain) on topics such as the measurement of large distances (in astronomy) the properties of crystals, the measurement of time intervals down to 10^{-9} second and the estimation of long intervals (including radioactive dating).

The second part of the course, dealing with optics and waves, starts from elementary ideas about shadows and reflections. A particle theory of light is prepared and used to discuss refraction and speed of propagation. A general discussion of wave motion on strings and on water leads to the wave theory of light, used to explain diffraction and interference. The properties of prisms, lenses and mirrors receive quite detailed treatment, though the spherical mirror is mentioned only as an approximation to a parabolic surface.

The exercises include the following as typical examples:

1. Suppose that someone were to propose to you that sound consists of small, rapidly moving particles that are emitted by a source and that affect your ear when they strike it. What evidence could you use to support or to refute it ?
2. Imagine our eyes were sensitive only to light of wave length 0.1 mm. How would this affect our ability to see ? Could you thread a needle ?

Part III introduces the student to the ideas of dynamics. The laboratory work, done with simple apparatus, is particularly important here. The distinction between inertial and gravitational mass is the subject of one experiment ; Kepler's law of equal areas is illuminated by another. Energy and momentum changes in collisions receive considerable attention. The idea of conservation of energy is discussed in relation to heat and molecular motion. Typical exercises include the following :

1. A man is at rest in the middle of a pond on perfectly frictionless ice. How can he get himself to the shore ?
2. Suppose there is a tiny sticky area on the wall of a container of gas. Molecules hitting this area stick there permanently. (*a*) Is the pressure there greater or less than on the ordinary areas of the wall ? (*b*) If the sticky region is cut out, leaving a hole, what is the pressure on the hole ? Be prepared to discuss your answers in class.

The final section of the book starts with a review of electrostatics and electric currents, leading to a study of the motion of charges in electric fields. Then come the magnetic field, electromagnetic induction and electromagnetic radiation. The closing chapters deal with nuclear structure, matter waves and quantum systems. This will be, for the student, the hardest part of the book; the treatment is thorough and there are many exercises more searching than the 16-year-old is usually offered. For example:

1. Find from part III of this book the average kinetic energy of center-of-mass motion of a molecule of a monatomic gas at room temperature, and its increase of energy when its temperature is raised 1°C. Suppose photons of 3-meter radio waves are given to the gas molecules. How many would raise the temperature 1°C ?
2. An alpha particle whose kinetic energy of 10^{-12} joules is scattered by a gold nucleus. (*a*) What is the minimum possible distance of closest approach ? (*b*) What must be the aiming error if the alpha particle is to get this close ? (*c*) How close could a proton of the same energy approach ? A neutron ?

The textbook is the centre piece of the course, carefully interlocked with the laboratory manual, the experimental equipment, the films and the supplementary literature. Some of the Science Study Series paperbacks have already appeared in Britain ; the teacher's Resource Book and Guide will be available shortly and it is likely that arrangements for the production of P.S.S.C. apparatus will also be made.

Here we have an educational experiment of unusual scope and concept. It is a salutary lesson to see how heavily our ideas on the content of the physics curriculum have become distorted through respect for tradition. The P.S.S.C. course uses the historical approach cautiously and only where it is relevant to the main theme. The emphasis throughout is on ideas rather than on machines, instruments and numerical calculations. The students (and the teacher) are continuously encouraged to think clearly and logically. No serious errors or misprints were found—though British readers may be disconcerted to see J. J. Thomson's familiar features over the caption " Ernest Rutherford ".

The results so far obtained in the United States are almost uniformly favourable and there can be little doubt that British experience will follow the same pattern, though some adjustments will certainly be necessary. The scheme, as it stands, is an admirable preparation for a university course in physics; it might also form the basis of an undergraduate course for non-scientists. In schools, it will hardly be possible to

complete the syllabus in one year without distorting the time-table unduly.

The P.S.S.C. textbook is a magnificent achievement. Sincere, concise and lucid, it conveys the true spirit of contemporary physics—the purposeful interrogation of nature.

J. M. A. LENIHAN.

THE WORLD OF MATHEMATICS

By James R. Newman

London: George Allen & Unwin. Four Volumes. Pp. 2535. Price 147s.

Of the making of anthologies it may be said that there is no end. But here is something quite outstanding and of a kind which makes it a law unto itself. Mr. Newman says in the preface that he has spent fifteen years (a much longer time than that originally envisaged) in the preparation of these four volumes, and one can well believe it. Seldom can a decade and a half have been better occupied. Before coming to a detailed discussion of the contents, a few general remarks may be permissible. The structure of the work is that each group of entries (fairly coherent in themselves) is introduced by a preface describing its general character and, in many cases, giving relevant biographical details of the mathematicians whose researches are set before the reader. In this way he is given a preview of the subject, enabling him to grasp the historical and intellectual climate in which the advances in question have occurred. Incidentally, these editorials, taken together, bind the whole collection into a consistent whole, which could scarcely have been achieved otherwise. In this they serve much more of a purpose than occasional contributions of this type usually contrive to do.

Moreover, there runs through the pattern of this assemblage a certain indefinable humility, which is an engaging quality; as if to leave the actors on the stage to speak for themselves (as most of them are assuredly entitled to do), while the announcer's part becomes more and more attenuated. Nevertheless, as the next phase of history comes into focus he is back at his post once more, ready to brief the reader gently but firmly as to what he is to expect to find next. But above all, the passages selected for study—and delight—are not easy. Some of them are the classics of mathematical literature, and must be treated as such. These are by no means arm-chair books.

Compilers of anthologies are fully entitled to include what they like, and to reject what they consider inappropriate. Mr. Newman realizes this, and admits a little bias—in favour of the theory of probability, and one or two other topics. He is perhaps a trifle ungenerous to Leibniz regarding the calculus, but fully makes up for this in placing him squarely at the beginning of symbolic logic, although he was not, during his lifetime, in a position to make much headway. This was left to the Englishman George Boole, with whom, as Lord Russell once remarked, mathematics as we know them may be said to have started.

When all is said and done, the advances of the nineteenth century are wellnigh incredible, even when every allowance is made for what intervening centuries have produced.

In terms of value, the possessor of this set of volumes is on sure ground. For what, under the circumstances, is a very modest cost he obtains, for example, the full text (the entire book in fact) of Philip Jourdain's priceless little work entitled *The Nature of Mathematics*, a monument to a creative character undaunted by crippling physical disability. Again, the essence of *Gödel's Proof* is included; normally but a slender booklet, it is a master piece of the art of explanation. And so on. Which is only to say that the material selected is long enough, and complete enough, for serious study. This is emphatically not a readers' digest.

However, a reviewer is supposedly allowed to react to omissions, subjective as such an attitude may be. There is nothing by Sir Joseph Larmor: he was a beautiful mathematical stylist, as great in the printed word as he was hesitating in speech. He represented too a philosophy of mathematical physics all his own, at once Hibernian and Victorian (not Victorian and Hibernian). And then there is the powerful Scott lecture by the late A. E. Milne, the founder of kinematic relativity, surely an outstanding composition, as well as profound in its brave suggestion of the place of " logical pressure " in discovery. These are but two items; there could be many more. But they are only mentioned because their standard is high enough to commend them to the editor's " axioms of choice ".

In the interests of factual accuracy, two minor points may be worth noting. Sir William Bragg was President of the Royal Society from 1935-40, not of the Royal Institution. And when distinguished scientists from abroad are admitted into the former, they become " foreign members " and not " fellows ".

Volume I begins with Philip Jourdain's stimulating contribution already mentioned. Then we have a series of historical and biographical studies by such honoured names as H. W. Turnbull, Maynard Keynes, Bishop Berkeley, Bertrand Russell and A. N. Whitehead, These display not only the evolution of mathematics, but the men behind it, and the great difficulties which they surmounted. After this comes a section on arithmetic and related subjects, which includes Newton's binomial theorem for fractional and negative exponents. Appropriately enough, we are then presented with Dedekind's basic work on irrational numbers. The volume concludes with a section devoted to the mathematics of space and motion, incorporating the labours of such masters as W. K. Clifford, Helmholtz and Weyl in their respective fields of space-theory, axiomatics and symmetry.

These records of a galaxy of talent need both to be fixed in time and anchored in place. The compiler has seen the desirability of this by including abstracts concerning Archimedes and the Greek mathematicians. The point at issue may be illustrated in this way. Archimedes, assuming the truth of the axioms and postulates of Euclid (and everything based upon them), was in fact able to deduce the transcendental number $\pi = 3{\cdot}1416\ldots$ Such an achievement had to wait for many centuries before it was repeated, in essentials, by Sir Arthur Eddington who, using the results of

twentieth-century physics was able to calculate the total number of particles in the universe, namely $2 \times 136 \times 2^{256}$. Now the basic epistemology of both these accomplishments may well be questioned (the first because it is now known that several of Euclid's axioms are not rigorously acceptable, the second because of the intrusion of certain metaphysical principles), but the pattern of the deductive method stands out, as the essence of all such triumphs. This is how science functions *au font*, no more and no less. The reader is confronted with the stark fact of what the human brain can do.

Volume II has perhaps a more direct appeal to working physicists. It starts with a section dealing with mathematics and the physical world. Then follows a portion on mathematics and social science, and finally, one on the laws of chance. The grouping of these particular subjects together might not, at first sight, seem wholly convincing. But once again, the commentaries form an excellent binding thread, and the reader is asked to realize in effect that in these activities mathematical science is ancillary (in the classical sense of a " serving maid ") to human needs. It is perhaps important to note that in these particular instances mathematics appears as a powerful tool, but not in the crude sense of mere empirical enumeration: more nearly perhaps as the best means we have of understanding nature, on the assumption that is that she is, almost without exception, rational. The question is taken up in a later volume—without however reaching an absolute conclusion—as to whether or not mathematical propositions exist independently of human reason: they might be " invented " by men of genius from time to time. Be that as it may, Wittgenstein thought the latter to be the case, but this may well have been connected with his loyalty to some form of logical positivism.

In the present context, we are regaled with some classics of physical research—the works, amongst others, of Galileo, Daniel Bernoulli, Moseley, W. H. Bragg, Schrödinger, Heisenberg, and Eddington, not to mention the concept of the periodic law of Mendeléeff. (It is good to find the latter in the same collection as Moseley's atomic number). And if it is desired to have a first-class literary treat, there is D'Arcy Thompson's " On Magnitude ", which covers the whole of nature in the grand style, and incidentally the theory of dimensions. Nobody else could possibly have written it.

Volume III provides a more varied spread, but some of the fare is of a rich delicacy. It opens with statistics and the design of experiments. Next—and something of a contrast—comes the supreme art of abstraction—Group Theory, followed by the mathematics of infinity, truth and structure. After these, we have a series of items dealing with the mathematical way of thinking, logic, and the question of " unreasonableness ". The concluding entries are in slightly lighter vein, namely " How to solve it " (by that remarkable teacher, G. Polya), the vocabulary of mathematics, and mathematics as an art. What is the unifying principle in all this ? On the whole, one feels that one is witnessing the birth of modern mathematics, with its accompanying travail. That is what these chapters portray. There is very little that is classical about them: they breath the invigorating air of nineteenth and twentieth century progress, almost as if to say with the Victorian prose writer, " World, world, I am coming ! "

In particular, Eddington discusses the theory of groups. Here is the supreme test of mans' power of abstraction. We have abandoned actors and actions and are left alone with structure : a calculus of pattern, and thus a knowledge of mathematical groups. Anticipating what will be said about the next volume, it may be observed meanwhile that certain aspects of the quantum theory some thirty years ago brought the subject into prominence, and added lustre to its achievements. Alongside all this, George Boole was practically founding symbolic logic, to be deepened and expanded by the Italian Peano, and reared to a mighty edifice in Whitehead and Russell's *Principia Mathematica*. And the end is not yet. Axiomatics and foundations are to-day being studied by specialists more exhaustively than ever. Polish logicians have not only advanced the frontiers of knowledge, but have re-interpreted Aristotle to a significant extent.

Volume IV, which contains an adequate index to the whole collection, is in keeping with the rest, more particularly in that, at least in part, it lays open the humanistic side of mathematics. It begins with " The mathematician ", and continues with a most apt and natural consequence, namely mathematical machines. Then follow mathematics in warfare, art, ethics and literature, music and culture. Finally, we are presented with essays on amusements, puzzles and fancies. These latter may be broadly entertaining, but they are mathematically rather dull. In fact, they are not quite " convenient ", in the Pauline sense of that adjective. This is not because they treat of fun and games, but because their mathematical content is trivial.

However, the contribution entitled " The Mathematician " already mentioned, by Professor von Neumann (No. 3) is outstanding. He touches the very heart and soul of mathematical research, and his warning is of real value. It is that concepts originally stimulated by some empirical factor are sound enough whilst they remain classical—in the architectural sense. But they require watching when they become baroque, or perhaps even flamboyant. Then they need a touch of the knife. This is set against the case of mathematical physics: there, investigators are usually intent upon overcoming some difficulty or inconsistency, which provides the necessary challenge and—as a rule—prevents the subject from going to seed. If one might with diffidence be allowed to broaden the author's imagery, the Gothic style intervened between the classical and the baroque, and it was this vertical element above all others that lifted men's thoughts to heights unknown before. Maybe that happens to mathematicians, as it were *en route*.

The gist of all this can be briefly stated. The emphasis is on pattern. And where there is pattern there is structure; and with structure realized, aesthetic contentment.

F. I. G. Rawlins.

ELECTRONICS AND NUCLEONICS DICTIONARY

By Nelson M. Cooke and John Markus

London: McGraw-Hill Publishing Company Ltd. Pp. 543. Price 93s.

This volume is a fully revised edition of a dictionary which has been used, largely in the U.S.A., for the last fifteen years, during which period a tremendous growth has taken place in each of the fields covered by the dictionary. Many versions of nuclear reactors and power generating equipment have been developed and built and the field of solid state electronics has moved from the theoretical physicist to the factory via the laboratory. The volume is well-produced, illustrated where necessary, and covers the fields of nucleonics and electronics very well. The British reader must be prepared for U.S. practice and nomenclature to be prominent in some entries. Nevertheless the dictionary is a scholarly work rather than a book of jargon. As far as could be determined, the terminology, hyphenation of compound words, and so on, were uniform throughout. Presumably the reviewer of a dictionary may test its accuracy and erudition by looking up words, likely and unlikely, as they come to mind. The first such attempt was to look for *perhapsatron* and this was found to be included. Materials developed in recent years such as indium phosphide are listed and general developments in solid state electronics are well documented. The entries under *infra red* where the topics are largely of military origin are up-to-date. New terms such as *tunnel diode* and *laser* are included.

One criticism of the dictionary is the absence of entries about fluctuation noise of the kind that is important in solid state devices. Thermal noise, shot noise and flicker noise of valves are listed but the excess noise or current noise of solid state devices is not. Information theory, fundamental to an understanding of communications systems, is also not listed.

These minor criticisms apart, the dictionary may be recommended as a reference work. The price will probably preclude its purchase by individuals but it will be welcome in technical libraries and perhaps even in company boardrooms.

C. A. HOGARTH.

INTRODUCTION TO QUANTUM MECHANICS

By Robert H. Dicke and James P. Wittke

Massachusetts and London: Addison-Wesley Publishing Company, Inc. Pp. xi + 369. Price 66s.

At a rough count there are about a dozen good textbooks in English on non-relativistic quantum mechanics. An author must therefore have firm confidence in his ability, and a publisher a good expectation of profit, to launch another on the academic world. Yet these books are not necessarily in direct competition. This is one of the most difficult subjects that is regularly taught to large numbers of students. The physical and mathematical ideas are strange, complex and numerous. There are subtle traps, high fences to leap in imagination, and always the feeling that the ground is not very solid beneath the feet. In such an enormous and treacherous territory there is need for many reliable guide books, to suit the speed and goal of every would-be traveller. A shelf of different treatises is a great boon to the teacher, who can recommend the appropriate volume to each pupil according to his ability and need.

This new work looks like being a formidable contender for one of the most profitable niches in this ecological system. It is designed for undergraduates and just-graduates on their way to doing fundamental research in atomic or nuclear physics, and covers fully the regions this side of second quantization. I would not say that it is quite elementary; one would need to assume a previous year on de Broglie waves and the structure of the hydrogen atom, and most people get along fairly happily without the density matrix (which is, however, done very well here). On the other hand, it is not too advanced; Hilbert space and group theory only get honourable mentions; the budding "theoretician" would need to go further. A judicious balance is, indeed, characteristic of the whole book, which seems to steer a most skilful middle course between mathematical formalism and physical intuition, between algebraic equations and verbal explanation, between abstract theory and the facts of nature, between rigour and intelligibility. Above all, it has the only necessary virtue of a didactic work: the essential point of each mathematical or conceptual step is explained clearly, so that the reader can see what is going on. The commonsense point of view, the clear style of writing, the elegant diagrams, the proper choice of type fonts for the symbols, the deliberate nonchalance about the details of normalization, are all admirable. I can suggest one or two things that might have been done differently—more worked examples in the text, more use of the Dirac notation, more perturbation theory (especially the degenerate case) and less about canonical transformations—but these are questions of personal taste and preference. This excellent book deserves to get a starred First for one simple reason: *one can see what is going on.*

J. M. ZIMAN.

THE NEW AGE IN PHYSICS

By Sir Harrie Massey

London: Elek Books Ltd. Pp. 342. Price 42s.

The purpose of this book is to explain, in non-technical language, the progress of physical science during recent years. The main topics discussed are atomic and nuclear physics, relativity, radio astronomy and upper atmosphere exploration—a wide range, reflecting the author's own interests. The treatment is generally quite straightforward, with little mathematical reasoning or calculation; consequently the book should be useful both to junior students of physics and to enquiring experts in other subjects.

Sections on atomic structure, wave mechanics and relativity are done in conventional style. Chapter 3 ("Mainly about electrons") brings together an interesting variety of subjects, including electron diffraction, semi-conductors, thermionic valves and transistors, low temperatures and electronic computers. The author's evident enthusiasm and flair for explanation are most fully revealed in chapters on cosmic rays and on the

neutrino—the last including a masterly account of right- and left-handedness in nature. Recent work with radio telescopes, rockets and satellites is well summarized in the final chapters.

In trying to cover such a wide and refreshingly original syllabus the author has inevitably found himself short of space at many points. The sections on particle accelerators and on radiation detection suffer noticeably ; the paragraphs on the uses of radioactive isotopes would be better omitted altogether.

Sir Harrie Massey has been badly served by his proof-readers. Inconsistencies of spelling (Muller, Möller and Müller ; radioastronomy and radio astronomy ; Payne-Scott and Payne-Smith ; Cowen and Cowan) are too frequent. Davisson appears throughout as Davison. The Calder Hall reactor is described as though the biological shield was inside the pressure vessel. The Stanford University travelling-wave electron linear accelerator is described as though it used the drift-tube principle.

The index is unhelpful. Apart from a few inaccuracies, it is pedantic to the point of eccentricity ; here are two typical entries :

Way, the Milky, 263, 266.
Year, International Geophysical, 259, 279, 282 ; light, 262.

These and other blemishes do not greatly detract from the considerable merits of the book—its simplicity of style, its freshness of outlook and its comprehensive coverage of modern physics—but they are numerous enough to be distracting and should be eliminated in future editions.

J. M. A. Lenihan.

THE HAZARDS TO MAN OF NUCLEAR AND ALLIED RADIATIONS

A Second Report to the Medical Research Council

London: Her Majesty's Stationery Office. Pp. vii+154. Price 7s.

The first report on the *Hazards to Man of Nuclear and Allied Radiations* by the M.R.C. committee was published in 1956. It drew attention to many blanks in our knowledge of the amount of radiation received by the population of this country. Since then much of the immediately available information has been gathered.

The second report contains a more accurate league table of the annual dose rate from various sources. Medical radiology is still second to the natural background, contributing 19 mrads per year to the gonads. The mechanism of atmospheric fall-out and the passage of ^{90}Sr through various food chains have been worked out in detail. An interesting addition (not discussed in 1956) to the fall-out picture is ^{14}C. Over half a ton of this isotope has been produced by weapon tests. In the long run it seems likely that ^{14}C will make the largest contribution to the gonadal dose from fall-out materials.

When the report deals with the effects, somatic and genetic, of the radiations it is clear that our understanding has advanced relatively little since 1956, in spite of the large amount of experimental work which has been carried out. On the genetic side it now appears as if the induced mutation rate might be substantially reduced if the total dose is received at low dose rates. The evidence is not yet strong enough to make the committee relax its former recommendations. There is a change in the maximum permissible concentration of ^{90}Sr in bone. Better understanding of the radiation dose from this isotope and on its distribution in the body has led to raising of the maximum permissible levels. These are now at least on order of magnitude greater than the actual ^{90}Sr levels being found in children's bones at the present time.

The report maintains the high standard set by its 1956 predecessor. The first 50 pages contains a summary of the experimental results with the conclusions drawn from them. The subsequent 100 pages are devoted to appendices which are really miniature review articles each complete with a bibliography.

J. M. Valentine.

CLASSICAL ELECTRICITY AND MAGNETISM

By E. S. Shire

London : Cambridge University Press. Pp. xvi+396. Price 45s.

The appearance of any book from the Cavendish Laboratory is an event of interest and consequently the present work will be very widely read and critically examined. The author quite naturally has taken one of the standard lines of approach available to teachers of electricity and magnetism which, though regarded by ascetics (and some others) as somewhat old-fashioned, is roundly and competently defended by the author in his preface. This line leads to the study of Maxwell's equations and a systematic treatment of electromagnetism from an elementary study of point charges and traditional electrostatics via magnetostatics (done here very well), current electricity, e.g. the study of the force between current elements, etc., conduction (here the author includes a few chapters on semi-conductors and related matters), electromagnetic induction and circuit theory including elementary a.c. theory, networks, etc.

Then following the chapter on electromagnetic waves there is a long and comprehensive chapter on electrical measurements and some 60 pages on various aspects of applied electricity. The latter part of the book includes a wide range of topics, for instance electrical machines (about nine pages), thermionic valves and transistors and electronic circuits and applied electron optics, i.e. mass spectrometers, particle accelerators, etc.

The book very clearly is the result of many years of experience in teaching a subject to discriminating students and is to be recommended. Any reviewer would naturally pick out items of outstanding personal interest to him and in these I would include particularly the sections on the proof of the inverse square law, coefficients of capacitance and induction, the brief treatment that is given of the relaxation method, the energy of fixed electrostatic systems, Ampère's experiments and the elementary theory of alternating currents and networks. It is arguable whether so much attention should be drawn to the early pioneer experiments but the author is well aware of this tendency and certainly should not be called upon to apologise for it.

There are excellent selections of problems.

J. D. Craggs.

BASIC PHYSICAL SCIENCE
By John C. Hogg and Judson B. Cross
Toronto and London : D. Van Nostrand Company Ltd. Pp. 282. Price 22s. 6d.

This delightful book, which seems finely adjusted to the times we live in, makes one wonder what the more enterprising school books of the next generation will be like. It also prompts some gratuitous reflections on physical science as part of a general education, on what I believe to be the false antithesis between literacy and numeracy, and on the dangerous heresy of the " two cultures ". The dreadful products of modern life are the literacy that wallows in emotion and stops short of the accurate use of words, and the numeracy that calculates strictly in terms of profit and loss so as to forestall kindness and generosity. Most people suffer from neither, but all our public life is organized on the assumption that everybody is animated by both. And there is *no* culture in an attitude or way of life that separates one from one's fellows ; you'd be far better off in a home. The fallacy of course, lies in assuming that education consists of " subjects " which obey Bose-Einstein statistics for the very young, but follow Fermi-Dirac statistics in the sixth form and beyond into later life. But the real purpose of education is to stimulate curiosity, and to satisfy that curiosity sufficiently to provoke it further, so that what the pupil thinks he " learns " is really becoming part of his life. This, rather than the ultimate use that may be made of the knowledge acquired, is the real justification for teaching science to children ; for in the scientific field the initial curiosity and the opportunity for its developments are greater. Few textbooks accept their responsibility in this light ; but *Basic Physical Science* really does so. The preface says " now is the time to delve a little deeper, to look for reasons. . . . The method of teaching should be closely allied to the way scientific information is obtained. The scientific method makes sense ; it is a way of life ; it is a natural approach to many everyday problems ".

There are six sections, of which the first explains simply the scientific method of approach to problems. Then follow Machines, Combustion and Fuels, Heat and Temperature, Light, and finally Transportation—an excellent survey of steam and internal combustion engines, aircraft, rockets and missiles. A range of stock elementary class experiments is included in the text, including one with pins and mirrors I am glad to say. I felt a little critical, as I had wondered how the authors would face this point, that in many cases the instructions went so far as to say what the result of the experiment would be. But at the chapter ends there are numerous simple experiments for the pupil to perform genuinely " unseen ", so that this is after all fair enough. And it will keep the teacher on his toes ; to refer to the preface again, the authors point out that an experiment that misfires wrecks the whole teaching approach, warns the teacher to rehearse his experiments, and exhorts him to extract the pupil's forecast of the outcome before looking at the text. The book should be in every common-room.

Some uncertainty as to what is meant by Grade Nine in Canadian schools makes it difficult to relate the material to a comparable course in England, but it seems appropriate to the fourth form of a grammar school. I should probably vote for some electricity at this stage (the electrolysis of water does appear in the section on combustion), but it is true that this leads to more unanswerable questions at this level if one pursues the authors' line honestly. The treatment follows the microscopic world down to the molecule very satisfactorily, and by going thus far and no farther lays a sound foundation for the later work which really requires a greater maturity if it is to be learned in this very rewarding manner.

G. R. NOAKES.

PRINCETON AERONAUTICAL PAPERBACKS
No. 3 GASDYNAMIC DISCONTINUITIES
By Wallace D. Hayes
Pp. 68. Price 11s. 6d.
No. 4 SMALL PERTURBATION THEORY
By W. R. Sears
Pp. 63. Price 11s. 6d.
No. 5 HIGHER APPROXIMATIONS IN AERODYNAMIC THEORY
By M. J. Lighthill.
Pp. 147. Price 16s.
No. 6 HIGH SPEED WING THEORY
By Robert T Jones and Doris Cohen
Pp. 243. Price 24s.
Princeton University Press. London: Oxford University Press

These four volumes in the Princeton Aeronautical Paperback Series are all reprints of articles already published in the volumes of the Princeton Series on High Speed Aerodynamics and Jet Propulsion.

Their publication in this form arises in answer, as the prefaces make clear, to " a demand for a wider distribution of certain portions of the Princeton Series and because it was felt desirable to introduce the series to a wider audience ". This venture is to be welcomed most warmly particularly in view of the expense of the complete volumes in the Princeton Series. The choice of the four volumes under review is most appropriate since all four represent very important contributions by eminent authorities to subjects which are fundamental to an understanding of high speed flow. Finally it should be remarked that it is the stated intention to make available only a small portion of the larger Princeton Series in this way, but one would hazard a guess that the idea will prove so popular that its scope will grow.

L. HOWARTH.

WHAT IS RELATIVITY ?
By L. D. Landau and G. B. Rumer. Translated from the Russian by N. Kemmer
Edinburgh and London : Oliver and Boyd. Pp. 64. Price (Limp Covers) 3s. 6d., (Boards) 6s.

If this were merely " a lighthearted presentation of the special theory of relativity ", as the blurb asserts, it would hardly have been written by two of Russia's most eminent physicists, or translated by one of Britain's. The remarkable fact is that this account manages to convey, by clever use of analogy and without any mathematics beyond the simplest arithmetic, the real spirit of the theory of relativity and as such can be read with profit by anyone engaged in the teaching of the

subject. At the same time, it can be appreciated by any intelligent fifth former.

The book starts with a discussion of the terms " absolute " and " relative ", using homely examples such as the difference between left and right to illustrate the latter, and gradually leads the reader to the relativity of speed and the difficulty in the concept of absolute rest. The experimental fact that the speed of light is constant then comes as an astonishing revelation. After this we are put on a train that moves at 240,000 kilometres per second and by a series of simple thought experiments we derive the contraction of length, time dilatation and the variation of mass with velocity. Only the identification of mass and energy is a little too glib. Throughout stress is laid on the inadequacy of common sense when applied to non-commonsensical situations, which is a much better way of presenting the theory than the usual method of popularization, which presents it as a succession of paradoxes, i.e. contradictions of common sense.

The book is delightfully and most appositely illustrated and can be recommended as a most excellent account of the special theory of relativity. It also offers a glimpse into the Russian mind. Lenin is quoted three times, though only once relevantly, and at one point we are told that 1 gm of radium was recently priced "according to foreign literature " at about £23,000. One concludes that in Russia it has no price—it is available to all who need it.

The reviewer cannot resist to quote the following two consecutive sentences from the book, in order to show that even the great Landau can slip :

" To discover our mistake we shall from now on rely only on statements that can be checked by experiment. Let us imagine a train 5,400,000 kilometres long moving in a straight line with a uniform speed of 240,000 kilometres per second ".

L. R. B. Elton.

Letters to the Editor

Optical illusions

Professor Tolansky's article on optical illusions brings to mind some intriguing and perhaps profound though ti about science and scientific method.

It is usual for scientists, and others, to claim that observation is the bedrock upon which all scientific theories are constructed, with the one restriction that these observations should either be reproducible or follow some distinguishable trend in time (e.g. the orbit of a planet). Now in the case of optical illusions we have the situation in which we have two conflicting reproducible observations. The evidence of our eyes tells us that lengths are unequal when a ruler tells us they *are* equal. In physics we reject the evidence of our eyes and believe the ruler, and pass on to psychology the problem of explaining the error of our visual judgement. Although in the circumstances this is not an unreasonable line to follow it does prompt one to ask whether in fact we should believe our judgement and not the ruler.

Perhaps this seems an absurd question to begin with, so let me broaden the issue somewhat. Optical illusions are perhaps the easiest illusions to demonstrate, but they are certainly not the only ones. We all know that our judgement of time is highly unreliable when compared with clocks. If we are bored or apprehensive time passes slowly, but if we are interested it passes rapidly. In other words, our judgement of time is strongly affected by factors not concerned with time at all. Similarly, our judgement of temperature, of hot water, for example, can be strongly affected by pre-conditioning in other bowls of water. Our judgement of weight is affected by fatigue and so on. All these can be classed as reproducible illusions when our opinions are compared with scientific standards.

It is clear, therefore, that science as a matter of course takes our various senses, finds that they are not adequately repeatable in terms of measurements by inanimate devices and so standardizes them. It substitutes weight for heaviness, time for our sense of time, wavelength for hue, frequency for pitch in sound, temperature for hotness and so forth. This it does for the very good reason that for the results of experiments to be reproducible and predictable the peculiarities of observers must be eliminated as far as possible. However, it does mean that the scientific view of the world tends to be quite different from that immediately available to us through our senses—or it would be if we were not so thoroughly conditioned to accepting our judgement as faulty if it is not confirmed by measurement.

Pursuing this kind of argument soon leads one to the conclusion that, scientifically speaking, much of what we see or hear or feel is illusory ! One wonders why we tolerate such impertinence from science. The answer, I think, lies in one of our senses, not often discussed, which to us is probably the most important we have and which science as yet has not attacked. I refer to our sense of pattern or shape.

From a scientific point of view, it is very remarkable that we can recognize a shape, say a triangle, immediately, whatever its size or whatever its angles, and however confused by intermingled curves, for a scientific instrument would have great difficulty in doing so. More remarkably, we can recognize a face with equal facility despite the dimensional similarities of faces in general;

indeed, dimensions as such, which are the tools of science, hardly affect the issue as evidenced by the fact that good cartoons are equally recognizable. Similarly, a tune is easily recognizable irrespective of the key or the absolute pitch of its notes. Obviously, science is missing something here. The technique science adopts to achieve the same result, and inevitably adopts, is to scan a shape, say, and plot intensity versus position, as in television, and in principle, a computer could be programmed to assimilate this information and come up with the answer that the shape was a triangle, or circle, or the face of Winston Churchill, or a cartoon of Winston Churchill. However, the complexity of this process soon becomes so vast as to make one doubt whether, as scientists sometimes suppose, this is the way the brain does it.

This takes me back to where I started. Perhaps for the purposes of understanding the world or how a human mind works, science has set off in the wrong direction, and should take more notice of how things appear to us instead of always preferring measured results. It needs a way of dealing with patterns as such. But we will not be so adaptable to scientific interpretations this time. If a scientific rationalization of my sense of pattern tells me my opinion of who my wife is or which is my house is illusory, I will not accept it, in the same way as I do accept the scientific corrections to my judgement of time, temperature, pitch, distance or length.

J. J. SPARKES (*A.Inst.P.*)

Furlong Down,
Jordans,
Bucks

Most of Professor Tolansky's optical illusions (*Bulletin*, January, pp. 1-6) can best be explained psychologically. Some are the result of answering a question different from the one which was asked. If asked which of two lines is the longer, we say which has the larger area associated with it. (Similarly in the "size-weight illusion", in which we are asked which of two bodies is heavier, when they are actually of the same weight but different sizes, we choose the smaller one—probably because it is heavier than it looks.) Professor Tolansky's explanation in terms of "drawing the eye inwards" is discussed, and shown to be unsatisfactory, by Woodworth (*Experimental Psychology*, Holt, New York; p. 648 in the 1946 edition).

The horizontal-vertical illusion of Figure 1 is probably the result of comparing the two lengths respectively with the horizontal and vertical axes of the field of vision, which is wider than it is high.

Professor Tolansky explains his Figure 8 by a physical effect of scatter or irradiation. If this is true, the illusion must persist even when the diagram is measured with a ruler; but it nearly vanishes when this is done, and I think the remaining effect is due to trouble in the photographic processes which have been used. The impressive illusions of Figures 9 and 11 are due not to "irradiation" but to the presence of large areas of white which outweigh the areas of black, and provide the basis on which we answer the wrong question.

A. C. LYNCH.

Potters Bar,
Middlesex.

The Teaching of Physics in Schools

The discussion upon the teaching of physics in schools raises the question, how far do the subjects taught for the A level examination serve as an introduction to more advanced courses ? Some indication may be given by the results of a test which was given recently to 25 students beginning a course for the Diploma in Technology in Applied Physics. Most of the students had passed A level in physics and mathematics, and the others had passed examinations of similar character.

There was not a single satisfactory answer to the question "What mechanical qualities are conserved in (*a*) an elastic collision, (*b*) an inelastic collision". Most of the students believed that momentum was not conserved in an inelastic collision. Only ten gave any reasonable definition of force, and of these only two wrote of "rate of change of momentum".

No student gave a valid definition of thermal conductivity. Apparently they had all been taught a "definition" in terms of a unit cube and unit temperature gradient. One would have supposed that any teacher of physics would appreciate the logical absurdity and didactic uselessness of such an approach. One consequence of the widespread use of this meaningless type of "definition" is ignorance of units. Thus only five students knew the units of resistivity, and eight knew those of specific heat. Incidentally, in the latter connection, only one student used the Joule as the unit of heat.

Not one student could define the steam-point, although three were nearly correct. None could define the candela, and enquiry showed that many had heard of no standard light source more modern than the sperm candle. Twelve students considered that a straight-line graph relating x and y proved that x was directly proportional to y. No one drew a satisfactory optical ray diagram of the human eye, although some considerable irrelevant anatomical knowledge was displayed. There was only one correct circuit diagram of a potentiometer being used to calibrate a voltmeter.

Some questions were set to examine quantitative ideas. No more than five students could estimate to within an order of magnitude the density of air at S.T.P. or the least angle resolvable by the human eye. Eight had reasonable ideas on the safe power dissipation in a resistance box coil (three estimated kilowatts !). The geometric mean of the estimates of the least current detectable by a moving-coil galvanometer was high by a factor 10^6. The question "Estimate the ratio (at room temperature) of the electrical conductivities of a good conductor and a good insulator" gave a geometric mean answer 10^{-18} times a reasonable value.

None of the results of this test was unexpected by the writer. In my experience the basic laws of dynamics are very seldom adequately taught at any level, which makes teaching such subjects as electricity, heat, and atomic physics an almost hopeless task. Few students appreciate the conservation of momentum, whilst it is generally believed that Einstein disproved the laws of conservation of mass and energy. The wide use of the misleading expression "conversion of mass into energy" adds to the confusion. Textbooks still refer to a force *causing* motion 300 years after Newton !

I am convinced that a radical change in physics syllabuses at all levels is most urgently needed. Above all, the amount of material should be drastically reduced. In the past syllabuses have been " revised " by adding more and more new material without removing any significant part of the great mass of out-of-date ideas.

J. W. WARREN.

Brunel College of Technology.

Mr. N. Clarke, replying to Mr. Spurgin's letter, states that the report is " concerned essentially with the basic approach of the teacher and with his appreciation of what are the fundamentals of physics ". Could Mr. Clarke be asked to tell us old teachers, who have had to do the best we could without much time to keep ourselves abreast of developments, what are the " fundamentals of physics " of which we are apparently so unappreciative.

I have tried to teach, for almost forty years, that assertions about this and that are quite valueless unless the meaning of " this " and " that " can be defined so that all, who use the terms, attach to them exactly the same meaning ; that science is an attempt to describe phenomena ; that the meaning of the concepts, the " this " and " thats ", which the scientist uses in this description, can only be defined by the phenomena, thus the meaning of any one concept is continually growing as it is found useful in the description of more and different phenomena. It is because I have these, no doubt, old fashioned ideas of the fundamentals of science that I, like Mr. Spurgin, doubt the wisdom of encouraging the use of such terms as atom, molecule, electron and wave, before the phenomena, which require these concepts for their description, have been encountered.

H. S. GERVIS.

Nortons,
Sherborne,
Dorset.

News of Members

FELLOWS OF THE INSTITUTE OF PHYSICS

A. C. Copisarow has been appointed Director of the Forest Products Research Laboratory, Princes Risborough.

H. H. Hopkins has received an honorary degree of the University of Besançon.

W. Hume-Rothery has been elected to Honorary Membership of the Institute of Metals.

Dame Kathleen Lonsdale has been appointed a Vice-President of the Royal Society.

J. L. Pawsey has received the Hughes Medal of the Royal Society.

E. D. van Rest has been appointed Assistant Director of Research (Operational Research) in the Engineering Department of the University of Cambridge.

G. W. Warren is now Head of the Department of Metallurgy at the Hirst Research Centre of the General Electric Company Ltd., Wembley.

ASSOCIATES OF THE INSTITUTE OF PHYSICS

W. Bosley is now Vice-Principal of Huddersfield College of Technology as well as Head of the Department of Physics.

J. A. Chaldecott has been appointed Keeper of the Science Museum Library.

M. E. Delany is a Temporary Senior Scientific Officer in the Applied Physics Division of the National Physical Laboratory.

R. E. Gee has joined the Group Research Department of A. E. Reed and Co. Ltd., Maidstone.

G. Haigh is now a Research Fellow in the Department of Cloud Physics, Imperial College, London.

J. R. A. Lakey has become Assistant Professor of Nuclear Science and Technology in the Royal Naval College, Greenwich.

D. G. Lampard has been appointed Professor of Electrical Engineering in the University of New South Wales, Sydney, Australia.

A. J. Mortlock has now taken up a Senior Lectureship in Physics at the Australian National University, Canberra.

J. L. Petrie has joined the Nuclear Plant Design Branch of the Central Electricity Generating Board, London.

K. H. Wilkinson has been appointed a Lecturer in Physics at Brighton Technical College.

GRADUATES OF THE INSTITUTE OF PHYSICS

J. A. Addby is an Experimental Officer at the Post Office Research Station, Dollis Hill, London.

D. Brooks is now a master at Nelson College, New Zealand, the school at which Rutherford was educated.

J. H. Bryce is a Physicist with Rolls Royce Limited, Derby.

P. C. Dench has joined Mullard Equipment Ltd. as a Development Engineer.

R. Gelder is an Assistant Health Physicist of the Nuclear Power Group at Berkeley Nuclear Power Station.

B. E. Matkins has joined Hawker-Siddeley Nuclear Power Co. Ltd., Slough, as a Physicist.

A. J. Millard is now a Development Engineer with Standard Telephones and Cables Ltd., Southampton.

Miss I. J. Nicol is now with I.B.M. Ltd., in Glasgow.

FELLOW OF THE PHYSICAL SOCIETY

B. H. Flowers has been appointed Langworthy Professor of Physics and Director of the Physical Laboratories in the University of Manchester.

Forthcoming Institute and Society Meetings

Date	*Place*	*Speaker*	*Title and other details*	*Time*	*Branch or Group*
Mar. 17	**Swansea** University College	Dr. R. A. Smith (*Royal Radar Establishment, Malvern*)	**Recent advances in physics of semiconductors**	5.15 p.m.	South Wales
Mar. 20	**Manchester** College of Science and Technology	Professor B. H. Flowers (*University of Manchester*)	**The structure of neutrons and protons**	7.00 p.m.	Manchester and District
Mar. 21	**Glasgow** The University	Dr. O. S. Heavens, F.Inst.P. (*Royal Holloway College, London*)	**Optical masers**	7.15 p.m.	Scottish
Mar. 21	**Newcastle-upon-Tyne** King's College	Dr. P. B. Hirsch, A.Inst.P. (*University of Cambridge*)	**Electron microscope studies of dislocations in metals**	6.15 p.m.	North Eastern
Mar. 22	**Birmingham** James Watt Memorial Institute	Dr. J. H. Davis, F.Inst.P. (*Bradford Institute of Technology*)	**Electronic reading machines**	6.30 p.m.	Midland
Mar. 22	**St. Andrews** St. Salvator's College, St. Andrews University	Dr. O. S. Heavens, F.Inst.P. (*Royal Holloway College, London*)	**Optical masers**	5.00 p.m.	Scottish
Mar. 23	**Aberdeen** The University	Dr. O. S. Heavens, F.Inst.P. (*Royal Holloway College, London*)	**Optical masers**	7.45 p.m.	Scottish
April 5 to 7	**London** Brunel College of Technology		Symposium on **Electrical contacts** Registration for this Symposium is necessary.		
April 6 and 7	**London** Headquarters		Conference on **Communication; Physics for the non-specialist** Registration is necessary.	10.00 a.m.	Education
April 6 and 7	**Glasgow** The University		Group Annual General Meeting and Spring Conference on **The crystal structures of organic compounds** Registration is necessary.		X-ray Analysis
April 12	**Birmingham** Birmingham Exchange and Engineering Centre	Papers presented by two student members	**Students' Evening**	6.30 p.m.	Midland
April 12	**London** Headquarters		**Generation of high magnetic fields for cryogenic purposes**	2.30 p.m. (or possibly all day)	Low Temperature
April 13	**Liverpool** The University	Dr. G. B. F. Niblett (*Atomic Weapons Research Establishment, Aldermaston*)	**Experiments on rapid magnetic compression of a plasma**	7.00 p.m.	Liverpool and North Wales
April 14	**London** Headquarters	Mr. D. H. Peirson, F.Inst.P. (*United Kingdom Atomic Energy Authority, Harwell*)	**Gamma-ray spectrometry**	2.30 p.m.	Applied Spectroscopy
April 14	**London** Headquarters	Dr. F. J. P. Clarke, A.Inst.P. (*United Kingdom Atomic Energy Authority, Harwell*)	**Fundamental mechanisms influencing the flow and fracture of some ionic solids**	6.30 p.m.	Non-Destructive Testing
April 17 to 19	**Birmingham** The University		**Nuclear physics conference** Registration for this conference is necessary. Programs and application forms are available from the Honorary Conference Secretary, Department of Physics, The University, Edgbaston, Birmingham 15.		
April 21	**London** Imperial College		Spring Visit to The New Physics Laboratories	3.00 p.m.	London and Home Counties
		Mr. H. J. Pain (*Imperial College*)	**Shock wave production of high temperatures** Registration is necessary.	5.30 p.m.	

Manuscripts accepted for publication in the Institute and Society's periodicals

British Journal of Applied Physics

The structure of non-destructive testing. By K. W. Andrews.
The physical basis of all non-destructive testing is emphasized. It is suggested that the ' structure ' (in a general sense) of non-destructive testing is based on two principle forms of energy, viz., the spectrum of electromagnetic radiations and fields and the spectrum of particle movements or vibrations in solids. The two are involved together or separately and are interpretable in terms of the structure (in a more physical sense) of the material, i.e. the electrons, atoms, molecules, crystal structure, etc.
A unified scheme of relationships is suggested. Reference is made to a fundamental unity of the equilibrium physical properties of a perfect crystal so that physical methods of examination are similarly inter-related. The ' real ' materials of industry and in particular metals can be regarded as derived from perfect single crystals by the introduction of increasingly serious forms of lattice ' imperfection ' or irregularity such as solid solution strains, vacancies, domains, dislocations, etc., leading to the eventual appearance of grain boundaries, poly-phase structures, segregation, etc. The way in which various physical properties are used to interpret materials in those terms is indicated.

Photographic technique for the determination of metal cutting temperatures. By G. Boothroyd.
An experimental technique has been developed for the measurement of the temperature distribution in the deformation zone and in the chip and tool during orthogonal cutting. The term orthogonal cutting is used for the special case where the cutting edge of the tool is perpendicular to the direction of relative motion of the workpiece and tool.
The method involves photographing the chip, tool and workpiece in a plane perpendicular to the cutting edge, using an infra-red sensitive photographic plate. The optical density of the plate is determined for the relevant field by means of a microdensitometer. A heated tapered strip, on which the temperature distribution is measured by means of a series of thermocouples, is photographed simultaneously with the tool and workpieces. This enables the optical density of the plate to be calibrated in terms of temperature, and the temperature distribution over the chip, tool and workpiece can hence be determined.
The effect of surface emissivity and of other factors on the accuracy of the technique are considered and the results of an experiment using the photographic technique are presented and discussed in relation to previous theoretical and experimental work.

A comprehensive study of the ion pumping of the noble gases. By B. Cohie, G. Carter and J. H. Leck.
The ion pumping of five noble gases by Bayard–Alpert ionization gauges has been studied extensively employing an ultra high vacuum system which could be operated statically or dynamically. The dependence of the important pumping parameters, initial pumping speed and maximum quantity of gas pumpable, upon gas composition, electrode potentials and gauge temperature have been investigated. The relationship between instantaneous pumping speed and the quantity of gas pumped has been deduced and observations upon the recovery of gas, following sorption, at ambient and elevated temperatures also made.
It is shown that the experimental results confirm a previously reported model of the sorption processes where gas ions enter a heterogeneous collection of capture sites of various energies of binding in the glass walls. The observed form of a static pump down is interpreted in terms of the kinetic processes which can occur at these sites.

Gaseous diffusion in porous media. Part 3 — Wet granular materials. By J. A. Currie.
The diffusion of hydrogen through granular materials partly saturated with water was measured by a non-steady state technique previously described. The two types of sample used consisted of solid particles (unimodal pore-size distribution) and porous particles (bimodal pore-size distribution), and all measurements were made on samples being dried from saturation. Coefficients of diffusion D were calculated, and for the range over which the larger pores were emptying the empirical equation $D_v/D_v(\varepsilon_v)^{\frac{4}{3}}$ fitted all materials, where ϵ is the fractional air-filled volume, ϵ_v is the volume occupied by the larger-pore phase, and where D_v is the diffusion coefficient when only this phase is air-filled. For all materials $\alpha = \frac{4}{3}$ whether the samples were uniform or of mixed size. No such relationship existed over the subsequent range in which the smaller pores were drained. Over this range D must be a function of at least five independent variables—the total porosity ϵ_T, the crumb porosity ϵ_c, the shape factor for the crumbs or inter-crumb pores k, the shape factor for the particles forming the crumbs or crumb pores k_c, and the moisture content of the sample. The spatial distribution of pores within a porous medium can be as important as the size of the pores. The factors k and m, previously introduced as particle-shape factors, now have a greater significance as measures of the geometrical complexity of a porous system. Adding water can either increase or decrease the complexity, depending on the amount added and the nature of the system. The agricultural significance of diffusion between the crumbs D_v and within the crumbs D_c is discussed, and it is suggested that D_v, or its associated complexity factor k_c, might be used as an index of soil structure.

Study of electric breakdown of liquid dielectrics using Schlieren optical techniques. By B. Farazmand.
The work is a contribution to the understanding of the mechanism of electric breakdown in liquid dielectrics. The liquid dielectric chosen throughout the experiments was *n*-hexane because an extensive literature exists on the breakdown of this material. The applied voltage was a rectangular pulse of different durations supplied from a 125 kv, five-stage Marx–Goodlet impulse generator. A novel rotary multiple electrode containing eight pairs of electrodes was incorporated in a simple and efficient fractionation–filtration unit. A protection circuit, incorporating an inverter and a trigatron, limited the duration of breakdown current.
A series of photographs of the state of *n*-hexane under the applied electric field was taken by Schlieren technique using a spark light source and a still camera. A statistical survey of the results shows the formation of a region of very low refractive index at the cathode. It is suggested that this is due to streamers with a very large number of branches, which propagate towards the earthed electrode. The rate of growth increases with voltage and above a certain voltage, if enough time is allowed, the stepped streamers bridge the electrode gap and breakdown of the liquid results.

The investigation of surface deformation. By L. Grunberg, D. Scott and K. H. R. Wright.
The methods for studying surface deformation used in the National Engineering Laboratory are described. Deformed metal surfaces show an enhanced photoelectric emission which is studied with the aid of open-ended Geiger–Müller counters or electron multipliers. Oxide films stripped from deformed metal surfaces are studied by electron-microscopy and changes in chemical reactivity by radioactive tracers. Surface topography is an important factor in lubrication and wear research and is being studied with the aid of interferometry, phase contrast and electron microscopy. Replica techniques are often applied with advantage.

SPECIAL ARTICLE

Galvanomagnetic effects and their application. By C. Hilsum.
The simple theory of Hall effect and magnetoresistance is discussed. The use of various semiconductors for galvanomagnetic applications is considered, and some practical applications described.

Recent advances in magnetic analysis. By K. Hoselitz.
Some recent developments in the examination of materials with the aid of the magnetization curve are described. The well-known method of estimating internal stresses by means of magnetic measurements has recently been much refined and these advances are discussed. It is also shown how the approach to saturation can be related to the dislocation density. A fair amount of information about non-magnetic inclusions and precipitates in a magnetic material can be derived from a critical assessment of its coercivity. On the other hand, the measurement of torque curves and of rotational hysteresis allows a comprehensive analysis of the shape, size and density of magnetic precipitates. Finally, the use of magnetic viscosity measurements for structure studies is mentioned.

Small signal impedance of a solid core inductance. By F. Kollar and R. D. Russell.
The design of a highly stabilized control system for a large electromagnet requires the knowledge of its small signal impedance as a function of frequency. The impedance of such an electromagnet was calculated, taking into account the effects of eddy currents but ignoring non-linearities in the magnetizing curve of the iron. It has been possible to use typical values for the relative incremental permeability and conductivity of iron to obtain a rather good estimate of its impedance over four decades above the lowest frequency, for which reactive components of the impedance are significant.
There is a change in slope in the curve of the magnitude of the impedance at a frequency corresponding to a skin depth equal to approximately $\frac{1}{2}$ of the radius of cross section of the core. Above this frequency the magnitude of impedance rises at 3 db per octave and the phase angle approaches 45°. At much higher frequencies the existence of stray capacities causes deviations from this predicted behaviour.

Simplifying the Fourier integral by adequate specification. By C. G. Mayo and J. W. Head.
No quantity can be measured exactly, but only within a tolerance, however small ; ' exact ' measurement would require infinite information. Likewise conceptual ideas such as ' unit impulse ' cannot be exactly realized, but they have realizable ' metrical ' counterparts, which are approximations within a tolerance specified in advance.
Most of the difficulties associated with the Fourier integral vanish if the conceptual impulse (Dirac delta function with Dirac's limit closed), which plays an important part in the derivation of that integral, is replaced by a form in which the limiting technique is maintained. This form may be regarded as the output voltage resulting when a conceptual unit impulse of current flows in a unit ' pure ' resistance shunted by residual capacitance. It can be represented as a function of time by the expression $(1/\eta)\exp(-t/\eta)$, where η, representing the residual capacitance, is vanishingly small but not zero. It is the presence of this quantity η which removes all ambiguities and difficulties.
In the usual treatment in terms of Jordan's lemma, a residual term is neglected which is estimated in terms of the size of a relevant integrand ; if, however, the oscillatory nature of this integrand is also taken into account, the residual is found, as here shown, to be an absolute zero.

SPECIAL ARTICLE

Amplification through stimulated emission — the MASER. By R. A. Smith.
The various factors which determine the ultimate sensitivity of a radio receiver are considered. External sources of noise (random electromagnetic fluctuations) are examined and the conditions determined under

which ultimate sensitivity is limited by noise generated in the receiver itself. The physical principles of emission and absorption of radiation are examined with particular reference to their application to the microwave region of the electromagnetic spectrum. The use of stimulated emission for amplification (MASER action) is considered and various methods for its exploitation are discussed. Different types of MASER amplifier are described and an elementary method of calculating their noise factors is given.

Recent applications of MASER amplifiers to radio astronomy and communications are described and some figures given to illustrate the large gain in ultimate sensitivity which has been obtained. Thus it is now possible to design an amplifier with noise equivalent to the input from a load at a temperature of only a few degrees K, and a whole system, including antenna and external noise from outer space, with noise equivalent to the input from a load at about 20°K.

Journal of Scientific Instruments

Technique using ^{85}Kr-labelled krypton for surface area measurements. By D. W. Aylmore and W. B. Jepson.
A simple volumetric apparatus for the determination of the surface area of solid materials is described. Isotopically labelled krypton (^{85}Kr) is used as the adsorbate and the pressure measured using a combined counting cell and Geiger–Müller tube. The apparatus can be used to measure areas of 0·01 m² to 1 m² with a precision of 5% for 0·025 m², 1% for 0·1 m² and 1·5% for 1 m².

Method of modulating a high intensity searchlight. By J. R. Bibby.
A rotating shutter was designed in order to modulate the beam from a large military searchlight at 5–10 c/s. Its construction is described, with notes on the modulated wave form produced.

The basis of verification of metal and glass Sikes hydrometers. By P. H. Bigg.
The basis of verification of metal Sikes hydrometers has been refined as the outcome of discussions between the Laboratory of the Government Chemist and the National Physical Laboratory. The refinement takes the form of the adoption of conventional reference conditions for the wetness of the hydrometer stem above the liquid surface and the surface tension pull acting on it. Corresponding refinement in the reference conditions associated with the glass hydrometers has been adopted by the NPL. These refinements will lead to greater consistency in verification and will not affect the ordinary calibration of Sikes hydrometers except for glass hydrometers used in very dilute solutions. Full details for the precise verification of both metal and glass Sikes hydrometers are given.

High sensitivity recording optical density meter. By K. E. Collins and D. J. Steele.
A recording optical smoke meter is described which has a high sensitivity. The optical density of smoke in a flue is compared by photoelectric means with that of an optical wedge, which is then rotated by an electrically operated servo system until the two densities are the same. The angular position of the wedge is detected by a transducer which provides a millivolt output proportional to the rotation of the wedge.
A multi-channel switching unit is incorporated which, electrically coupled to a recorder, enables any number of different flue units, up to the capacity of the recorder, to be used, or other variables to be recorded at the same time.
The range of the instrument can be varied by changing the value of the optical wedge in the balancing unit or by varying the transducer output to obtain full scale deflection of the recorder for any desired rotation of the wedge.
The calibration in terms of millivoltage output against optical density is linear, provided the optical wedge and output transducer have linear characteristics. The output is stable to ±0·6% of full scale reading for ambient temperature changes in the range of 55°–80°F, and the sensitivity is such that densities of the order of 0·005 can be recorded.

Calculator for solving electron irradiation problems. By E. H. Cornish.
A discussion is given of the factors involved in the accurate radiation dosimetry of objects bombarded with initially monoenergetic electrons. It is necessary to match the incident electron energy with superficial density in the case of a parallel-sided target in order to attain uniform dose distribution. A preferable procedure is to employ the maximum electron energy available and to use a beam filter of suitable thickness, interposed between the electron source and (in contact with) the target. Such a combination minimizes the maximum overdose given.
Another concept described is that of average dose factor, which arises because of the asymmetry of the normal ionization curve.
Details of a simply made instrument are given, enabling electron dosimetry calculations to be made by a mechanical analogue of the normal ionization curve. It shows values for optimum electron energy, filter thickness required, and also for average dose factor, once the superficial density of the target is known.

Time-resolved spectrograph for use with triggered light sources. By F. L. Curzon and J. R. Greig.
Details are given of a time-resolved spectrograph with writing speeds up to 5 mm/μsec (at *f*/12) which can be used to view weak light sources. The main limitation is that the light source must be able to be triggered reproducibly. This is necessary as the increased effective light intensity needed to obtain a usable image density in the camera of the spectrograph is produced by the accurate superposition of the light of many discharges.
An experiment is described which shows that the superposition of fifty successive discharges has been achieved with an overall variation of less than 0·3 μsec.

Some results obtained in developing a recording Geiger counter x-ray intensity monitor. By A. E. Kiss and N. Patla.
A single-beam monitor is described which samples the general background radiation scattered from an x-ray beam by a thin foil, and its behaviour compared to that of the main spectrometer counter receiving the K component from the same beam. Equal fractional changes of counting rate for monitor and main counter are observed when x-ray beam fluctuations are caused by changes in the x-ray tube current. No such simple relationship holds between monitor and main counter for changes in x-ray tube voltage. The response required of a counter for monitoring purposes is discussed briefly and the suitability of an end-window argon-filled Geiger counter established experimentally.

Differential volumeter for measuring minute volume changes in solids. By R. Lowrie and F. Slish.
The design and use of a differential volumeter reproducible to ±5 p.p.m. of sample volume are described. Volume changes of solids not soluble in or reactive with mercury can be followed at temperatures from 25 to 250°C, by changes in the meniscus level in a capillary attached to an otherwise closed reservoir which contains the sample. Data on volume changes during the annealing of cold-worked titanium are presented as an example of the application of this instrument.

Plastic capsule technique for the combustion calorimetry of volatile or chemically reactive compounds : the heat of combustion of polythene. By H. Mackle and R. G. Mayrick.
A technique for vacuum-forming polythene capsules for use in the combustion calorimetry of volatile or chemically reactive compounds is described. It has a number of advantages over the glass-ampoule method. Values for the heat of combustion of polythene are reported.

Mechanical trace reader. By E. W. Northover.
A simple mechanical trace reader is described which enables deflections recorded on paper or film to be read off, on a dial gauge, in any desired units when a movable cursor is set to the required points on the trace. Its use is illustrated for evaluating recorded temperatures at various points and times in a thermal model for the study of heat flow in the strata surrounding a mine airway. The trace reader gives a direct indication of the temperature difference ratio $(\theta r - \theta o) / (\theta_0 - \theta o)$ where θr is the temperature at the point in question and θ_0 and θo are fixed temperatures. It can be used in many other applications provided that there is a linear relationship between the recorded quantity and trace deflection.

Automatic compensation for thermal e.m.f.'s and galvanometer zero drift in a feedback fluxmeter. By T. M. Palmer.
Slow drift of a feedback fluxmeter is prevented by resistive feedback in addition to the differentiating circuit. Before a measurement the resistive path is opened whilst maintaining the voltage for zero drift.

Vacuum radiation furnace with precise control of temperature gradient for crystal growth by sublimation. By A. G. Prior.
The furnace was designed for the growth of lead selenide single crystals at 775°C. It provides an inherently high degree of temperature uniformity and, without the use of a servo control system, the gradients can be adjusted and maintained to less than 1/10th deg c/cm and 1 deg c in 10 cm. A changed gradient can be established in five minutes. In heating from cold a steady temperature is attained in 75 minutes, and the furnace can be cooled in a few minutes. This performance is achieved by minimizing the total mass of heated material, and by the use of highly reflecting water cooled silvered surfaces for the walls. An outline is given of the regulating system for controlling the absolute temperature to 0·1 deg c. Evaporation of the alloy heater elements limits the maximum temperature to about 940°C, but this should be raised by the use of other elements.

Oxide resistor furnace for high temperature operation. By E. Rothwell.
A thoria-base oxide resistor furnace has been constructed for operation at temperatures up to 2400°C in an oxidizing atmosphere. The maximum temperature attainable is limited by the ionization of the air in the vicinity of the oxide resistor and simple means of overcoming this limitation are suggested. The furnace may prove attractive for some specialized investigations where the requirement of an oxidizing atmosphere is sufficient to over-ride the inherently fragile nature of the resistor element.

Design for a three-circle x-ray goniometer. By R. W. H. Small and S. Travers.
Using the scheme first described by Furnas and Harker, for the collection of three dimensional intensity data from a single crystal in which the motion of the counter tube is restricted to a horizontal plane, a comparatively simple instrument has been designed. Particular attention has been given to the design of simple bearings which are free from backlash and wear, and which permit the recording of diffracted beams up to an angle of 2θ of 165°. The instrument has provision for scanning and recording integrated intensities over an arc of 4°. Some details of performance are given.

Tensile testing machine for whiskers. By H. B. M. Wolters and F. W. Schapink.
A screw-driven micro tensile tester for whiskers is described. A synchronous motor moves one of the grips at a constant velocity, whereas the second grip is connected to a load cell in which a differential transformer is employed.

Sensitive electrostatic meter with a balanced reed. By Y. L. Yousef and Miss S. A. Zaher.
A new electrostatic meter is described for measuring by a null method resistance, capacity, power loss and power factor over a considerable range of values at mains frequency. The action of the device depends on the vibrations which are set up in a thin aluminium reed initially at rest under the influence of two opposite alternating electrostatic forces. It is arranged that the quantity we wish to measure upsets the equilibrium in these forces, but balance may be restored to 10^{-4} by the adjustment of a potentiometer and/or a resistance. The theory is discussed and typical examples of the various applications are given.

The preparation of continuous single-crystal thin films of nickel and nickel–iron alloys. By J. C. Anderson, O. S. Heavens, R. F. Miller and G. L. Moss.

Thin films of nickel and some face-centred cubic nickel–iron alloys have been grown epitaxially from the vapour phase on to the principal planes of rock salt and copper, and their structure and orientation investigated by transmission electron microscopy. Conditions have been determined for the production of continuous films of thickness down to 100Å. The mass and composition were determined microchemically ; thicknesses given are on the assumption of bulk density.

Spin–lattice relaxation in imperfect cubic crystals and in non-cubic crystals. By E. R. Andrew and D. P. Tunstall.

An examination is made of the spin–lattice relaxation in the solid state of nuclei whose energy level spacings are rendered unequal by quadrupole interactions with the crystalline electric field. Attention is directed to two special cases : (1) when the main field is suddenly increased from zero, and (2) after saturation of the central line of the resonance spectrum ; in the case of imperfect cubic crystals this is the only observed line. In general $2I$ relaxation times characterize the relaxation behaviour, though in the two special cases the effective number is reduced. Detailed calculations of the relaxation behaviour have been made for spin number 3/2 and 5/2 for a quadrupolar relaxation mechanism. The behaviour in the two special cases differs and to a degree which depends on the relative strength of quadrupolar relaxation by transitions involving $\Delta m = 1$ and 2. The relevance of the results to the experiments of Day and Squire on potassium iodide is discussed. Magnetic relaxation is also treated and an expression is found for the $2I$ relaxation times.

Angular correlations in the reactions ^{18}O $(\alpha,n\gamma)^{21}Ne$ and ^{22}Ne $(\alpha,n\gamma)^{25}Mg$. By W. M. Deuchars and D. Dandy.

The angular correlation of the gamma radiation from the first excited states of ^{21}Ne and ^{25}Mg, in coincidence with neutrons, has been studied using an axially symmetric neutron counter at 0° to the incident beam direction. Our results for ^{21}Ne (together with lifetime measurements on the first excited state of ^{21}Ne) show that the first excited state has spin and parity $5/2^+$ and that the magnetic dipole, electric quadrupole ratio is $0{\cdot}004 \leqslant \delta \leqslant 0{\cdot}03$.

The g_J value of the 6^3P_1 level in mercury. By J. N. Dodd.

A redetermination of the g_J value of the 6^3P_1 level in mercury using the ' double-resonance ' technique is described. The value is in agreement with recent measurements using the ' level-crossing ' technique but not with the value obtained in earlier experiments. A weighted mean of all determinations suggests the value $g_J = 1{\cdot}48631 \pm 0{\cdot}00008$.

The phonon-assisted Auger effect in semiconductors. By D. M. Eagles.

Some calculations on the effect of phonons on Auger recombination and impact ionization in semiconductors with simple bands are presented. It is shown that phonon-assisted Auger recombination could be the dominant recombination mechanism in highly-doped, high energy gap semiconductors at low temperatures, and that at low carrier-temperatures the rate of phonon-assisted impact ionization can be greater than the direct impact ionization rate.

Proton–proton scattering below 50 MeV. By J. Iwadare.

A simple interpretation of the results of detailed phase shift analyses is presented for the low energy p–p scattering. It is seen that, in general, there are four sets of phase shift solutions, two of which correspond to the right sign of the tensor potential. One of them corresponds to the pure tensor potential, the other to a mixture of the tensor and the L.S potentials. To decide between these two possibilities the combined measurements of C_{nn} and one of the triple scattering parameters are the most convenient and feasible experiments. It is also shown that the Japanese pion potential is compatible with the angular distribution below 5 MeV.

Reflection and polarization of elastic waves in a LiF crystal : mode conversion from longitudinal to transverse. By N. Joel.

An experiment is described in which a longitudinal wave of ultrasonic frequency travelling in a crystal of LiF (anisotropic medium) is incident on a crystal–air boundary and is reflected as a transverse wave. Such a mode conversion, or complete change in the state of polarization, of an elastic wave had previously been observed only in isotropic media. The corresponding calculations are also given ; they agree with the experimental results.

Space charge limited current flow and deep trapping in Se. By H. P. D. Lanyon and W. E. Spear.

Current–voltage characteristics of evaporated specimens of vitreous Se have been studied. They show an ohmic part at low applied voltages and, with increasing hole injection, a V^2 region which precedes the trap filled limit as predicted by Lampert's theory. Ohmic contacts of Te or Pt were formed on newly prepared specimens by the prolonged application of a moderately high electric field, but this was not found possible with a low work function electrode such as Mg. The detailed analysis of the results from formed specimens between 2 and 31μ thick indicates the existence of a volume distribution of hole traps of density 9×10^{15}cm^{-3}, 0·79 ev above the valence band. These values agree with independent results from measurements of the transient photoconductivity after saturation of the centres with strong illumination. At room temperature the average trapping time is 50 seconds leading to a capture cross section of 8×10^{-14}cm^2. The presence of the 0·79 ev level offers some explanation for the pronounced difference between the absorption and photoconductive edges in vitreous Se. It is concluded that the level lies near the upper edge of a comparatively dense distribution of states extending towards the valence band.

The statistical properties of sequences of stochastic pulses. By T. Lukes.

Two methods are presented for treating sequences of random pulses which are applicable to cases where the distribution of periods, durations or intervals is known. The methods are shown to lead to identical results and enable the correlation functions, after-effect functions and spectra to be calculated. The results are applied to typical sequences ; some existing results are shown to be particular cases of the theory presented.

Evaluation of molecular integrals by a numerical method. By E. A. Magnusson and C. Zauli.

Numerical integration in elliptical coordinates is proposed as a convenient method for the computation of most types of two-electron molecular integrals including some types of three- and four-centre integrals, and in some cases, of one-electron two- and three-centre integrals. This method removes a great deal of the burden of analysis and in addition lifts many of the restrictions on the form of the orbitals which are imposed by existing methods.

For Slater-type orbitals general formulae are given to facilitate the calculation of two-centre Coulomb integrals, hybrid repulsion integrals and certain three-centre integrals. Explicit expressions are listed for integrals involving orbitals of the first, second and third quantum shell.

Some theoretical considerations on the longitudinal magnetic field induced oscillations in semiconductors (the Oscillistor) and a tentative explanation. By A. C. Prior.

The conditions under which oscillations have been observed are shown to be such that a system of transient circulating currents can arise. These currents will tend to increase the carrier concentration at one surface of the specimen, and thus modify the surface recombination. Oscillations of a relaxation type could plausibly result. The model suggests variation of frequency and amplitude with magnetic field intensity and direction, and with electric field and temperature similar to that reported, and could account for the occurrence of incoherent oscillations with an accurately aligned magnetic field.

Viscosity and thermal conductivity of binary gas mixtures : krypton–argon, krypton–neon, and krypton–helium. By E. Thornton.

The coefficients of viscosity and thermal conductivity of binary mixtures of krypton with argon, neon and helium have been determined over the full range of composition of each mixture at a pressure of 70 cm of mercury and at a temperature in the range 18·0 to 18·3°C. The experimental values are compared with theoretical values based on the Lennard-Jones (6–12) potential of interaction between molecules. Agreement between the experimental and calculated values is generally satisfactory, but there are discrepancies between some of the measurements given here and those of other workers.

Collective modes in the theory of superconductivity. By D. J. Thouless and D. R. Tilley.

Some results which were derived by use of finite temperature perturbation theory are used to investigate the possibility of a low-energy collective mode in a superconductor. It is found that such a mode should exist, and the ratio of its energy to its momentum is calculated. This ratio approaches infinity exponentially as the temperature goes to zero, in agreement with Anderson's result that at zero temperature the collective mode is destroyed by the Coulomb force. The effect of this collective mode on the specific heat is negligible. The relation of this mode to ' second sound ' is discussed. A comparison is made between the behaviour of this collective mode in a charged superfluid system (superconductor) and the behaviour of the collective modes in a superfluid system of neutral fermions.

LETTERS TO THE EDITOR

An energy level of ^{24}Mg at 6·44 MeV excitation. By S. Hinds, R. Middleton and A. E. Litherland.

Relative intensities in the triplet system of CO bands. By N. L. Singh and D. C. Jain.

UNITED KINGDOM ATOMIC ENERGY AUTHORITY
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SIR JOHN CASS COLLEGE
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HEAD OF DEPARTMENT OF PHYSICS

The Governors of Sir John Cass's Foundation invite applications for the post of Head of the Department of Physics which will become vacant on September 1, 1961, on the retirement of Mr. R. H. Humphry, M.Sc., F.Inst.P.
Full-time and part-time courses for the B.Sc (Special) Physics and the B.Sc. (General) Internal degrees of the University of London, together with research for higher degrees and postgraduate courses on special topics form the major part of the work of the department. Students are also prepared for the Graduateship examination of the Institute of Physics.
Candidates should have the qualifications, teaching and research experience necessary to secure recognition as a teacher of the University of London.
The salary is on the scale of £1,800 × £50–£1,950 with London Allowance of £38 or £51.
Further particulars and forms of application may be obtained from the Secretary.

Central Electricity Generating Board

RESEARCH AND DEVELOPMENT DEPARTMENT

Berkeley Nuclear Laboratories

PHYSICS DIVISION

Applications are invited for a number of posts in the Physics Division of the Berkeley Nuclear Laboratories, Gloucestershire. Persons appointed will initially work in the following sections, although subsequent transfer between sections will be permissible, depending on the developing interests and abilities of the staff concerned.

A. SOLID STATE PHYSICS

To study the fundamental processes of radiation damage and other related effects in irradiated solids. *X-ray and electron microscopy facilities are available.*

B. THEORETICAL PHYSICS

To study various theoretical problems of interest to the Laboratory, including reactor physics and the theory of radiation damage.

C. REACTOR PHYSICS

To study experimental sub-critical reactor problems and experiments connected with the Board's reactor programme. *In view of the growing demand for reactor physicists, these posts are of considerable interest to young men with energy and ability, who wish to enter this field.*

D. INSTRUMENTATION

For work developing nuclear radiation detectors and other specialized nuclear instruments. *Preference will be given to candidates who are capable of devising and developing new techniques of measurement.*

E. GRAPHITE

To study the fundamental mechanisms of irradiation damage in graphite and the corresponding changes of physical properties. *To assess the extent of irradiation damage of the graphite in the Board's reactors.*

Salaries up to £1,325 p.a. will be fully commensurate with experience, ability and qualifications.

The Board's salary scales for Scientific Staff rise to £2,395 p.a. Opportunities for promotion are excellent and will depend entirely upon the contributions made by the successful candidates to the work of the Department.

Preference will be given to candidates with a good honours degree. They should be under 26 years of age.

Applications stating age, qualifications, experience, present position and salary, and indicating section of interest, to the Appointments Officer, 24/30 Holborn, London, E.C.1, as soon as possible. Envelopes should be marked "Confidential Ref. PB/73".

THE COLLEGE OF AERONAUTICS

Applications are invited for the post of RESEARCH PHYSICIST in the DEPARTMENT OF MATERIALS to conduct research into the fundamental mechanisms of deformation and recovery in GRAPHITE. Candidates should have a good background in metal physics or in metallurgy, and experience of X-ray diffraction or electron microscopy techniques would be valuable. Previous experience with graphite is not essential. The salary will be within the range of £1,000 to £1,575 per annum, depending on experience and qualifications; with superannuation under F.S.S.U. and family allowance. Appointment will be made initially for three years with prospects of continuation. Applications containing full particulars and quoting the names of three referees, should be addressed to the Recorder, The College of Aeronautics, Cranfield, Bletchley, Bucks.

VICTORIA UNIVERSITY OF WELLINGTON
NEW ZEALAND

RESEARCH PROFESSOR IN NUCLEAR PHYSICS

The Council of the Victoria University of Wellington proposes to appoint a Research Professor in Nuclear Physics within the Department of Physics and invites enquiries or applications from suitably qualified persons. An important function of the Research Professor will be to prosecute research work within the Institute of Nuclear Science which is situated in the Wellington area. The salary will be at the rate of £2,800 per annum. Approved fares to Wellington will be allowed for the appointee, his wife and his dependent children. In addition, actual removal expenses will be allowed within certain limits. Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in New Zealand and London on May 1, 1961.

UNIVERSITY OF GLASGOW
LECTURESHIPS IN EXPERIMENTAL AND THEORETICAL PHYSICS

Applications are invited for Lectureships in Experimental and Theoretical Physics. Salary scale: Senior Lecturer—£1,750–£2,275 per annum; Lecturer—£1,050–£1,850 per annum. Grade of appointment and initial salary according to experience and qualifications. F.S.S.U. and family allowance benefits. Successful applicants will be expected to prosecute research preferably in Nuclear or Elementary Particle Physics in addition to teaching duties. Applications (eight copies), including the names of two referees, should be lodged, not later than April 15, 1961, with the undersigned, from whom further particulars may be obtained.

Robt. T. Hutcheson, Secretary of University Court.

RADIOLOGICAL PROTECTION

The AUTHORITY HEALTH AND SAFETY BRANCH advises on the standards necessary to ensure protection from ionizing radiations, and on the way in which the standards are to be applied to safety evaluation of reactors and plant.

We urgently need suitably qualified men to carry out this programme and can offer excellent opportunities to people with experience of radio-activity or of radiation measurement and dosimetry.

HARWELL

In the **RADIOLOGICAL PROTECTION DIVISION** there are vacancies for the following:—

(a) A PHYSICIST to lead a team assessing radiation dosimetry techniques and health physics instrument design and specification.

(b) A SCIENTIST to lead a team advising on the control of radiation and radioactive contamination, including monitoring and protective clothing.

(c) A TRAINING OFFICER to advise on radiological protection syllabuses and the technical content of training films, together with some lecturing.

(d) A SCIENTIST to lead a team assessing the environmental aspects of radioactive waste disposal.

(e) A MATHEMATICIAN or Mathematical Scientist to apply mathematical and computer techniques to radiobiological problems, e.g. metabolism and radiation dosimetry of human tissues.

RISLEY

(f) A SCIENTIST for work on health physics assessments associated with nuclear reactors with particular reference to reactor siting.

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Posts (a)-(e) will be in the Principal Scientific Officer grade, and post (f) will be in the Senior Scientific Officer grade. Additional Scientists in the Senior Scientific Officer grade are needed.

Applicants should have a first or good second class honours degree and be 26 years of age or over, and have at least three years postgraduate experience. Salaries will be within the following scales:—

£1,840 to £2,590 or £1,640 to £1,770

Contributory Superannuation, Staff Housing Schemes.

Please write for application form, quoting reference H.19/J.106 to:

Administration Manager, **U.K.A.E.A., Authority Health and Safety Branch, Harwell, Didcot, Berkshire**

UNIVERSITY OF CANTERBURY
CHRISTCHURCH, NEW ZEALAND

Applicants are invited for appointment as SENIOR LECTURER IN MATHEMATICS at a salary of £1,750 0s. 0d. per annum rising by annual increments to a maximum of £2,000 0s. 0d. per annum. Commencing salary will be in accordance with qualifications and experience. The appointee will be required to take charge of an IBM 1620 computer and to instruct courses in computer programming and in numerical mathematics. Previous experience of a computer would be an advantage, but the appointee will receive instruction on the 1620 machine. Approved fares to Christchurch will be allowed for the appointee, his wife and children. In addition actual removal expenses will be allowed within specified limits. Further particulars and information as to the method of application should be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in New Zealand and London on March 10, 9161 or as soon as possible.

WESTMINSTER HOSPITAL
DEPARTMENT OF CLINICAL MEASUREMENT
SENIOR TECHNICIAN

This Department deals with applied physics, chemistry and physiology in clinical practice and requires a Senior Technician. Applications to be in I.M.L.T., Physics or Cardiological grades or to have similar scientific experience. Salary, according to qualifications and experience, in scale £710 - £870 p.a. plus London Weighting. Apply, naming two referees, to Secretary, Westminster Children's Hospital, Vincent Square, S.W.1.

RESEARCH STUDENTSHIPS IN PHYSICS AND BIOPHYSICS. Applications are invited from Honours Graduates in Physics, Chemistry or in a Biological subject, for Studentships available in October, 1961, leading to the degrees of Ph.D. in Physics or in Biophysics (University of London). The aim of these Studentships (tenable in the Department of Physics) is to provide facilities for basic training in the branches of physical and biological science appropriate to the peaceful uses of atomic energy. The Studentships normally extend over three years and carry an allowance of £400 p.a. Detailed applications, naming two referees, should be received by the Secretary, Institute of Cancer Research, 33 Sumner Place, S.W.7, not later than April 30, 1961 quoting reference 305/B.

FULMER RESEARCH INSTITUTE LIMITED

METALLURGISTS and PHYSICISTS required for crystallography and for studying high temperature materials and uranium alloys. Applicants should preferably have a good honours degree and postgraduate experience. Salaries for three vacancies in the range £1,000 – £1,500 p.a. Superannuation Scheme. Applications to : Director of Research, Fulmer Research Institute Ltd., Stoke Poges, Buckinghamshire.

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NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY
St. John Street,
London, E.C.1
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Applications are invited from graduates or holders of the Diploma in Technology for appointment as RESEARCH ASSISTANT to work in one of the following fields :— X-ray crystallography, semi-conductors, illumination, electron microscopy, ultrasonics. Successful applicants will be encouraged to submit a thesis for the Membership of the College of Technologists, or a Higher Degree. Their duties will include a limited amount of demonstrating in the laboratories. Salary about £500 per annum. Further particulars may be obtained from the Secretary.

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY
St. John Street,
London, E.C.1.
DEPARTMENT OF APPLIED PHYSICS

Applications are invited for the post of ASSISTANT LECTURER IN PHYSICS, which arises from an increase in establishment. The teaching activities of the Department are primarily concerned with sandwich courses for the Diploma in Technology in Applied Physics together with physics or an ancillary subject for other Diplomas in Technology courses. Applicants should possess an Honours Degree, or an Honours Diploma in Technology in Applied Physics. It is desirable that applicants should have research or industrial experience in some branch of Applied Physics. The successful candidate will be expected to take part in the research activities of the Department ; excellent experimental facilities are available. Salary scale £930 × £27 10s. 0d. – £1,400 per annum. The starting salary will be dependent upon industrial or teaching experience. Further particulars and a form of application may be obtained from the Secretary.

UNIVERSITY OF NEW ENGLAND
Armidale, New South Wales
LECTURER IN PHYSICS

Applications are invited for a lectureship in the Department of Physics. Commencing salary will be determined in accordance with qualifications and experience, within the range £A1,730 × £105 – £A2,435 per annum, plus a cost of living adjustment which is at the moment £36 per annum. Superannuation and assistance in the buying or building of a house will be provided for a permanent appointee. Further particulars about the position and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on April 30, 1961.

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